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TEST REPORT ON VIBRATION MEASUREMENTS ON THE C-141 LASER TEST

Analytical Structural Mechanics Branch (AFRL/VASM)
Structures Division
Air Vehicles Directorate
Air Force Research Laboratory, Air Force Material Command
Wright-Patterson Air Force Base, OH 45433-7542

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Final Report for 01 August 1976 – 26 September 1978

Approved for public release; distribution is unlimited.

AIR VEHICLES DIRECTORATE
AIR FORCE RESEARCH LABORATORY
AIR FORCE MATERIEL COMMAND
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NOTICE

This technical report has been reviewed and is approved for publication.

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This test report presents data which define the vibration environment of a chemical laser system on a C-141 aircraft. These data were needed to determine if there are any severe vibration problems due to the abnormally large amount of weight added by the laser system to the C-141 petal door area.

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WRIGHT-PATTERSON AIR FORCE BASE, OHIO

STRUCTURES AND DYNAMICS DIVISION

TEST REPORT
ON
VIBRATION MEASUREMENTS ON THE C-141 LASER TEST

REPORT NO: AFFDL/FBG/79-9

DATE: August 1979

PROJECT NO: 431G5000

PROJECT ORDERS: WAL72108P, WAL82210P, WAL92453P

TYPE OF TEST: Measurement of Vibratory Environment

REQUESTED BY: AFAL/WRD-2

I. PURPOSE

This test report presents data which define the vibration environment of a chemical laser system on a C-141 aircraft. These data were needed to determine if there are any severe vibration problems due to the abnormally large amount of weight added by the laser system to the C-141 petal door area.

II. BACKGROUND

The Air Force Avionics Laboratory (AFAL) planned a flight test program of a chemical laser system in a C-141 aircraft out of the 4950th Test Wing to determine potential hazards in the operation of this system due to the abnormally large amount of weight added to the petal door area. The 4950th Test Director, the AFAL Project Engineer, and test engineers from AFFDL/FYS and FYT (now FBG) held two preliminary planning meetings on 9 September 1975 and 14 April 1976 to determine the exact nature of the test. On 17 May 1976 AFAL formally requested the Structural Vibration Branch (FBG - formerly the

Field Test and Evaluation Branch) to make vibration measurements on twenty-two components in the laser reactor, exhaust, and gimbal assemblies. The request originally required forty-six accelerometers for the twenty-two locations. Later, additional locations were instrumented by FBG to include angular vibration measurements and brought the total number of accelerometers to sixty. The vibration tests were to be made on two test flights.

Personnel of AFFDL/FBG prepared a preliminary test plan during August 1976 and, at the request of 4950th/FFAO, submitted a final revised test plan on 15 June 1977. Also, AFFDL/FBG prepared preliminary drawings for 4950th/FFAO in August 1976 and updated modification proposal on 15 June 1977. AFFDL/FBG prepared a portable data acquisition package (PDAP), mounted sixty accelerometers within and near the laser, and calibrated and checked the PDAP on the aircraft. The 4950th Mod Center mounted the PDAP on the floor in the cargo area of the C-141, mounted a switch box within the laser assembly and a remote control panel in the test directors rack, and routed cables and wiring between the PDAP and the switch box, accelerometers, and remote control panel as specified by AFFDL/FBG. Personnel from 4950th/FFAO operated the PDAP during the two vibration test flights that were flown on 18 September 1978 and 26 September 1978. The data were analyzed in FBG's data analysis facility.

III. SUMMARY OF RESULTS

Descriptions of the C-141 laser test configuration, instrumentation, test procedure, data reduction, and a discussion of test results are presented in Appendix A. Tables, figures, and photographs are presented in Appendices B, C, and D, respectively.

The data were analyzed for two cruise conditions: Low Q (150 kts/24 kft) and high Q (350 kts/18 kft). Preliminary analysis verified an acceptable signal-to-noise ratio over the frequency bands analyzed.

The linear vibratory environment is presented as maximum and average power spectral density curves for sets of accelerometers grouped according to location and measurement direction. The maximum overall RMS level for the 1-2000 Hz frequency range was 2.4 g's. The main spectral contributions were from the pallet and laser areas in the vertical direction.

The angular vibratory environment is presented as angular displacement amplitude spectra derived from pairs of linear accelerometers oriented at specific locations to yield pitch, roll, and yaw data. The highest overall RMS level for the 10-1000 Hz range was 162 microradians pitch at the turret strongback.

IV. CONCLUSIONS

The dynamics data presented in this report are considered to be an accurate definition of the vibration environment of the chemical laser system on the C-141 aircraft.

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PUBLICATION REVIEW

This test report has been reviewed and is approved.

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APPENDIX A

Test Configuration, Instrumentation, Test Procedure, Data Reduction, and Test Results (Refer to Appendix B for Tables, Appendix C for Figures and Appendix D for Photographs)

Test Configuration

The test article is a chemical laser system called LIDS, Laser IRCM (Infrared Counter Measures) Demonstration System, fabricated for the Air Force Avionics Laboratory (AFAL) under a contract with Hughes Aircraft Company. The laser system, which weighs approximately 5,000 pounds, was mounted by the 4950th Mod Center on the rear ramp of 4950th Test Wing's C-141A tail number 61-2779 in the area of fuselage station (FS) 1382.00. Ballast was added to the forward section of the aircraft to balance the large amount of weight of the laser system at the rear of the aircraft.

Figure 1 is a copy of a 4950th Test Wing profile drawing which lists the major components of the LIDS and shows the component locations on the C-141A. In addition, sketches (provided to AFFDL at a 1975 meeting) of the laser reactor assembly, laser exhaust assembly and laser reactor support structure are included as Figures 2-4 respectively.

Several photos of parts of the laser system are included in Appendix D. Photo 1 shows the LIDS as it appears when viewed from behind the rear ramp with the ramp up. Photo 2 gives a side view of the LIDS as it appears when looking from the left hand side of the aircraft, and Photo 3 shows the LIDS as it appears from the inside of the aircraft when looking aft. The aluminum shroud covers the laser as indicated in Photo 3. Some of the major components are pointed out in the photos.

Instrumentation

Originally, forty-six accelerometers and one angular rate sensor were to be installed by AFFDL to obtain the required vibration data during the two test flights. As a result of changes in requirements, the final instrumentation incorporated a total of sixty accelerometers with some pairs of accelerometers being located so as to obtain angular vibration data in addition to linear vibration data.

The instrumentation block diagram of the total AFFDL data acquisition system is included in Appendix C as Figure 5. The portable data acquisition package (PDAP) consisted of a Leach tape recorder, master and secondary amplifier boxes, time code generator, power cube power supply and a power box. The components of the PDAP were mounted on a 1/2" thick aluminum plate measuring 42" x 24". The PDAP was mounted on the floor (WL 146.0) of the C-141 via cargo tie down points at fuselage station FS 870.00 between the systems analysis table and hydraulic cooler as shown in Figure 1. The PDAP is shown as installed in the C-141 in Photo 4.

Since the PDAP is basically a twelve channel recording system, a switch box located inside the laser reactor assembly at RBL 14.75, WL 227.5, FS 870.00 was wired for five positions so that a group of twelve accelerometer signals could be selected in each switch position for recording by the PDAP. By cycling through the five switch positions, all sixty accelerometer signals were recorded by the PDAP. The accelerometer numbers that correspond to each of the five switch positions are tabulated in the small table at the bottom of Figure 6.

An AFFDL fabricated remote control panel was installed in the test director's rack and is shown in Photo 5. This panel was included in the data acquisition system so that the 4950th operator could control recorder start and stop functions, switch position selection, and amplifier gain inhibit control from a convenient location.

The tape recorder on the PDAP was set up for a tape speed of thirty inches per second (ips), allowing vibration data to be obtained over a frequency bandwidth of about 2 Hz to 10kHz. In addition to the twelve tracks of the tape recorder utilized for FM recording of accelerometer data, track 13 was used to record amplifier gain status information (commutator signal), track 14 was used to record time from the PDAP time code generator (standard IRIG-B time code), and edge track 15 was used to record voice from the aircraft intercom system.

The sixty accelerometers were mounted at the locations described in Tables 1A and 1B by gluing mounting studs and mounting blocks (cubes) to the structures defined in Tables 1A and 1B with Ecobond 51 epoxy. Single axis accelerometers were screwed onto #10-32 threaded mounting studs, and dual and triaxial accelerometers were attached to mounting blocks by means of insulated mounting studs which had #10-32 threaded studs on opposite sides to mate with the #10-32 holes in the mounting blocks and the accelerometers. Photos 6 through 29 show the actual installations of accelerometers 5 through 60. Accelerometers 1 through 5 were not located in areas accessible for picture taking. As a result of an unexpected glue bond failure on Accelerometer 1, before the first test flight, it was left off for the test flights due to the potential of its falling off again and possibly striking one of the expensive, highly polished mirrors in the gimbal. Figure 7 is a sketch of the accelerometer locations used for angular vibration data.

Figure 8 is a plot of the accelerometer locations utilizing the aircraft coordinate system. In Figure 8 the fuselage station is along the longitudinal axis and is measured from the nose of the aircraft. The butt line is along the lateral axis and is measured left and right of the fuselage center line. Water line is measured along the aircraft vertical axis starting from the bottom edge of the fuselage.

All accelerometers used were Columbia Model 902H piezoelectric crystal accelerometers (.625" diameter x .700" high) which had an average sensitivity of 9 millivolts/g. The output signal from each accelerometer was routed through the switch box (when in the appropriate switch position) and into one of the twelve automatic gain changing (AGC) amplifiers in the two amplifier boxes. The AGC amplifiers automatically selected the gain required (from -10 through 60dB in 10dB increments) for presenting an optimum voltage level signal for the Leach tape recorder. When the operator activated the inhibit switch, all twelve amplifiers locked up at their current gain setting until the inhibit was again deactivated.

Installation of the instrumentation was accomplished from September through November 1977. FBG installed the accelerometers and mounting blocks and studs in the appropriate locations. The 4950th Test Wing personnel mounted the switch box, remote control panel, and PDAP supplied to them by FBG. The 4950th technicians routed all of the required interconnecting cables between the accelerometers, switch box, remote control panel, bulkhead connectors, and PDAP using drawings and guidance provided by FBG.

Test Procedure

Before instrumentaion installation in the aircraft, all of the accelerometer sensitivities were verified in the laboratory and the switch box, remote control panel, and PDAP were completely checked out. In addition, a series of random noise records on all twelve tape tracks in each of the five switch positions were made so that phase corrections required between tracks could be made when analyzing the pairs of accelerometers set up for collection of angular vibration data.

In November 1977, right after the vibration system installation was completed, calibration signals were recorded on tape by using the insert cal technique. This technique consists of using a portable test oscillator and calibration box to insert a sine signal simulating a known value of g's at the accelerometer end of the signal line. The conditioned signal that is recorded by the PDAP is then used to determine the correction factor that needs to be applied to the accelerometer sensitivity derived in the laboratory. Using this technique, the analysis group obtained an overall system sensitivity in terms of millivolts/g, which compensated for system signal losses due to cable lengths between the accelerometer and recorder, switch box contact resistances, and other loading effects.

During the period of 19 December 1977 to 19 January 1978, no vibration test flights were flown because of aircraft unavailability and checkouts being performed on other systems on the aircraft. On 19 February 1978, the aircraft's left rear petal door broke causing postponement of the vibration flight until repair of the petal door was completed in June 1978. Before the first vibration test flight, several more checkouts of the instrumentation were made by FBG including remounting accelerometers, rechecking calibrations, making no-signal records in all amplifier gain steps and switch positions, and checking system noise levels.

The first vibration test flight was flown at Wright-Patterson AFB, Ohio on 18 September 1978 and data were collected for the flight conditions shown in Table 2A. The remaining flight conditions were flown at Eglin AFB, Florida on 26 September 1978 and data were collected for the flight conditions shown in Table 2B.

During the test flights the PDAP was operated by 4950thTW/FFAO personnel following the operating procedure provided by FBG. The operating procedures are included in Tables 2C and 2D for takeoff and landings, and straight and level flight conditions, respectively.

Data Reduction

Data reduction was accomplished at the FBG facility. The analog data tapes were played back and all data channels displayed on oscillograph strip charts to check data validity and to select areas for further analysis. These areas were:

1. No signals.

2. Low Q flight condition (150 kts/24 kft). Records 27-31 on 26 September flight tape.

3. High Q flight condition (350 kts/18 kft). Records 47-51 on 18 September flight tape.

The data were digitized for digital processing and analyzed using standard FFT (Fast Fourier Transform) techniques. For all analyses, ensemble averaging of transforms were performed to increase statistical confidence.

As a preliminary analysis to determine the frequency content across the entire data frequency range, power spectral densities (PSD) in units g^2/Hz were computed for all accelerometers for the frequency range 0-10kHz with a resolution of 16.289 Hz. The "No-Signal" PSDs were overlaid on the "High-Q" PSDs to determine the signal-to-noise ratio across the spectrum. All subsequent analyses were performed with finer resolution for the frequency range 0-2kHz.

The linear vibratory environment was determined by PSD analysis of all accelerometers with a frequency range of 2kHz and narrowband resolution of 1.2207 Hz. To further reduce this large quantity of analyses for each of the three test conditions, the PSDs were combined by computing the maximum and average values for each narrowband. The resulting maximum PSD and average PSD were then plotted on the same graph, presenting a type of envelope of the PSD levels across the analysis range. This technique was repeated for different subsets of the PSDs to determine the contribution of vibration levels and frequencies from four locations (gimbal, pallet, laser, and turret) and the three directions.

The angular vibratory environment was estimated using pairs of linear accelerometers oriented at specific locations so that the difference of their signals would yield either pitch, roll, or yaw data. The individual linear accelerations for each transducer pair were digitized, phase-corrected, and then differenced. An amplitude spectrum analysis with 1 Hz resolution was performed on the acceleration difference. This result was then divided by the separation distance, integrated twice, and scaled to obtain an angular displacement spectrum in microradian units.

Test Results

Preliminary analysis: Figure 9 is a typical result of the 10kHz preliminary analysis. The frequency components in the "No-Signal" data but not in the flight data are from the ground power unit which was on during "No-Signal" recording. The signal-to-noise ratio was generally higher in the 0-2kHz range. Consequently, the final analyses were restricted to that range, permitting a much finer frequency resolution. Though the signal-to-noise ratio is acceptable in this analysis range, it is probably the limiting factor in the overall accuracy.

Linear Vibration: The results of the analysis to determine the linear vibratory environment are presented as maximum and average PSD curves in Figures 10 through 19. The indicated RMS value in each figure is calculated from the maximum PSD values.

Figure 10 shows the "No-Signal" condition results, verifying that the recording noise levels were below the data levels for the low and high Q flight conditions. The main frequency component at 400 Hz and its harmonics are from the aircraft power unit.

For the "High-Q" flight condition (cruise at 350 kts, 18,000 ft altitude) the maximum and average PSD curves for all accelerometers are shown in Figure 11. The sources (and direction) of the more significant peaks across the spectrum are indicated along the frequency axis. These data are then broken out according to the four general locations (gimbal, laser, pallet, and turret) in Figures 12 through 15. They are also broken out according to measurement direction (vertical, lateral, and longitudinal) in Figures 16 through 18.

For comparison, data from another flight condition of relatively low Q (cruise at 150 kts, 24,000 ft altitude) was similarly analyzed. The PSD levels were generally low except for certain frequencies from the laser location as shown in Figure 19. Some laser components (such as pumps) may have been operating during the low Q condition but not during the high Q condition, thus causing some of the higher levels in Figure 19.

Overall, the linear vibratory environment appears to be at a fairly low level for the cruise conditions with the main contributions being from the pallet and laser areas in the vertical direction.

Angular Vibration: The results of the analysis to determine the angular vibratory environment are presented by amplitude spectra in displacement units (microradians) in Figures 20 through 26. Due primarily to noise floor considerations, this type of analysis procedure (angular displacement from linear acceleration differences) is considered to have valid results only in the frequency range of 10-1000 Hz. (References 1 and 2). The amplitude levels are relatively low, the highest being a pitch of 70 microradians at about 12 Hz for the turret strongback.

REFERENCE

1. "Prediction of the Angular Response Power Spectral Density of Aircraft Structures" by Lee, Obal, AFFDL-TR-78-188, December 1978.

2. "Measurement of Angular Vibration Using Conventional Accelerometers," by Whaley, P.W., and Obal, M.W., Shock and Vibration Bulletin, September 1977, pp 97-107.

APPENDIX B

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TABLE 1A. ACCELEROMETER LOCATIONS (#1-37).

ACCEL. #	LOCATION DESCRIPTION	AC ORIENTATION	ANGULAR AXIS	A/C BL	A/C WL	A/C FS
1	Center Underside of Beam Expander-In Gimbal Aft.	Vert.		R14.75	191.75	1434.85
2	Center Face of Modulator Shrould-In Gimbal Fwd.	Vert. (Tilt)		R15.00	192.00	1405.60
3	Main Housing of Power Calorimeter on Black Plate-In Gim. Fwd.	Vert.		R15.00	201.00	1407.85
4	Bottom of Bracket Holding Laser Fix & 6FE Laser Mirror-In Gimbal Fwd.	Vert.		R15.00	190.75	1397.10
5	Around Center of Turret Baseplate-In Gimbal Aft.	Vert.		R12.50	176.00	1438.85
6	IR Receiver Bracket	Vert.		R16.75	179.50	1441.85
7		Lat.				
8	Mounting for Relay Mirror # 3-In Gimbal Aft.	Vert.		R10.00	184.50	1445.35
9		Lat. (Tilt)				
10	Mounting for Relay Mirror # 1-In Gimbal Aft.	Vert. (Tilt)		R13.75	198.00	1442.35
11	Centered About a Point on Cargo Deck, 37" from # 12	Vert.	Roll	R38.50	146.00	1258.00
12	on hydraulic pallet.	Vert.	Roll	R 1.50	146.00	1258.00
13	Centered about a Point on Cargo Deck, 40" from # 28	Vert.	Pitch	R20.00	146.00	1238.00
14	On Optical Bench Laser Center Line at Edge under Laser Head	Vert. (Tilt)		L24.75	217.00	1393.50
15		Lat.				
16		Long. (Tilt)				
17	On Reactor/Assembly Support Structure Near Elbow/Scrubber	Vert.		L35.25	221.50	1354.00
18		Lat.				
19		Long.				
20	On Reactor Assembly Support Structure Near Scrubber/Heat Exch.	Vert.		R28.25	224.00	1380.50
21		Lat.				
22		Long.				
23	On Reactor Assembly Support Structure Attachment to Strongback	Vert.		L25.75	221.5	1351.00
24		Lat.				
25		Long.				
26	LN2 Dewar Module-Flat Surface on Top	Vert.		R 5.75	205.0	1360.00
27		Lat.				
28	Centered About a Point on Cargo Deck, 40" from # 13	Vert.	Pitch	R20.00	146.00	1278.00
29	On Cavity Fuel Bottles	Vert.		L35.25	208.0	1361.0
30		Lat.				
31		Long.				
32	On Exhaust Ducting Elbow Between Bellows at Forepump Input	Vert.		R 0.25	215.0	1333.00
33		Lat.				
34		Long.				
35	On Cooling Pump Bracket	Vert.		R29.25	195.5	1384.5
36		Lat.				
37		Long.				

TABLE 1B. ACCELEROMETER LOCATIONS (#38-60).

ACCEL. #	LOCATION DESCRIPTION	AC ORIENTATION	ANGULAR AXIS	A/C BL	A/C WL	A/C FS
38	On Roots Blower Housing	Vert.		R40.00	213.0	1330.00
39		Lat.				
40		Long.				
41	On Forepump Housing	Vert.		L40.25	217.0	1331.00
42		Lat.				
43		Long.				
44	On Bottom of Strongback Interface Surface	Vert.		R26.25	228.5	1387.00
45		Lat.				
46		Long.				
47	On Housing Just Above Turret, 10" from # 48	Long.	Yaw	R20.00	177.00	1428.85
48		Long.		R10.00	177.00	1428.85
49	Centered about a Point on Cargo Deck Just Fwd of the Strongback Attachment, 10" from # 50 on hydraulic pallet	Vert.	Pitch	R20.00	146.6	1253.00
50		Vert.	Pitch	R20.00	146.6	1263.00
51		Lat.	Yaw	R20.00	146.6	1253.00
52		Lat.	Yaw	R20.00	146.6	1263.00
53		Vert.	Roll	R25.00	146.0	1258.00
54		Vert.	Roll	R15.00	146.0	1258.00
55	Centered on Top of Strongback Just Above Turrett, 10" from # 56	Long.	Yaw	R10.50	205.0	1258.00
56		Long.	Yaw	R20.50	205.0	1447.00
57		Vert.	Roll	R10.50	205.0	1258.00
58		Vert.	Roll	R20.50	205.0	1447.00
59		Vert. (Tilt)	Pitch	R15.00	215.5	1443.25
60		Vert. (Tilt)	Pitch	R15.00	218.0	1433.75

TABLE 2A. TEST CONDITIONS 18 SEP 78 VIBRATION TEST FLIGHT

REC #	SWITCH POSITION	PRESSURE ALTITUDE(X1000ft)	AIRSPEED (KCAS)	COMMENTS
1	1	0	0	GROUND RUNUP
2	2			235,000 lbs GW
3	3			
4	4			
5	5			
6	1			TAKEOFF
7	1			LANDING
8	2			TAKEOFF
9	2			LANDING
10	3			TAKEOFF
11	1	18	150	
12	2			
13	3			
14	4			
15	5			
16	1	18	200	BAD RUN REC 17
17	2			
18	2			
19	3			TAPE 1 ENDED
20	3			
21	4			
22	5			
23	1	18	250	SPOILER OUT
24	2			
25	3			
26	4			REC 26 BAD
27	5			
28	1			BAD REC
29	1	18	250	NO SPOILERS
30	2			
31	3			
32	4			
33	5			
34	1	18	280	
35	2			
36	3			
37	4			REC 37 FREE RUN
38	4			
39	5			REC 39 TURN ABORTED
40	5			
41	1	18	300	
42	2			REDO
43	2			
44	3			
45	4			
46	5			
47	1	18	350	
48	2			HYDRAULICS ON
49	3			PUMPS ON
50	4			END TAPE 2
51	5			START TAPE 3-THIS RECORD MADE 26-9-78

TABLE 2B. TEST CONDITIONS 26 SEP 78 VIBRATION TEST FLIGHT

REC #	SWITCH POSITION	PRESSURE ALTITUDE(X1000 ft)	AIRSPEED (KCAS)	COMMENTS
1	3	0	0	TAKEOFF HEAVY
2	3			LANDING - VTH=126
3	4			TAKEOFF
4	5			LANDING
5	5			TAKEOFF
6	1	24	250	
7	2			
8	3			
9	4			
10	5			
11	1	24	200	
12	2			REC 12 - BAD RUN
13	2			
14	3			
15	4			REC 15 - STARTS SLOW
16	5			
17	1	24	300	
18	2			
19	3			
20	4			
21	5			END TAPE 3
22	1	24	350	START TAPE 4
23	2			
24	3			
25	4			
26	5			
27	1	24	150	FLAPS 50° DOWN REC 28-31
28	2			
29	3			
30	4			
31	5			
32	1	18	280	PUMPS ON COLD FLOW
33	2			
34	3			
35	4			
36	1			LANDING
37	1			TAKEOFF
38	2			LANDING TURN & GO
39	3			TOUCH & GO
40	4			TOUCH & GO
41	5			TOUCH & GO
42	5			LANDING LAST RECORD
43	4			TAKEOFF

NOTE: Accelerometer #13 loose from mounting on this flight.

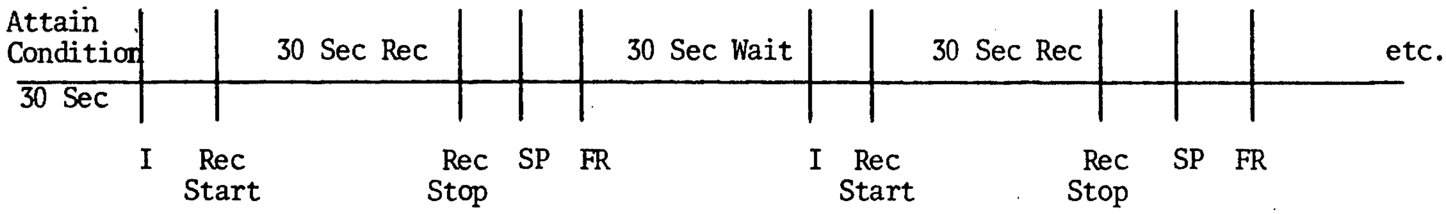
TABLE 2C. INSTRUMENT STANDARD OPERATING PROCEDURES (ISOP) DURING TAKEOFF AND LANDINGS.

STEP	TIME	INSTRUCTION
1	Taxi	Recorder turned off.
2	Runup	Turn recorder on.
3	Takeoff	Turn inhibit on at operator's estimate of highest vibration level.
4	Turn from runway heading on takeoff	Turn recorder off.
5	Begin landing approach	Turn recorder on.
6	Touch Down	No action
7	Landing roll out	Turn recorder off.
8	Taxi	If last record of switch position go to next switch position.* If not continue.
9	Taxi	Turn inhibit off and go to Step 1.

* Go to next switch position immediately after recorder turn off so that transients due to switching do not occur on the next record.

CAUTION: Wait at least 21 seconds between switch position change (Step 8) and recorder turn on (Step 2).

TABLE 2D. INSTRUMENT STANDARD OPERATING PROCEDURES DURING STRAIGHT & LEVEL TEST CONDITIONS.



<u>INSTRUCTIONS</u>

1. Step switch to pickup Group 1. (SP)
2. Attain desired test condition.
3. Switch to Inhibit. (I)
4. Start Recorder. (Rec Start)
5. Stop Recorder after 30 sec record is complete. (Rec Stop)
6. Step switch to next pickup group. (SP)
7. Switch to free run. (FR)
8. Wait 30 seconds and enter info on log sheet.
9. If pickup group = 1, go to Step 2. (i.e. New Test Condition)
10. If pickup group $\neq$ 1, go to Step 3. (i.e. next record for present test condition)

NOTES: 1. There is approximately 12min record time/tape, so check tape supply at about 11 minutes total record time.

2. AFFDL circuit breaker is located on No. 4 panel first one in the bottom row near the recorder pallet.

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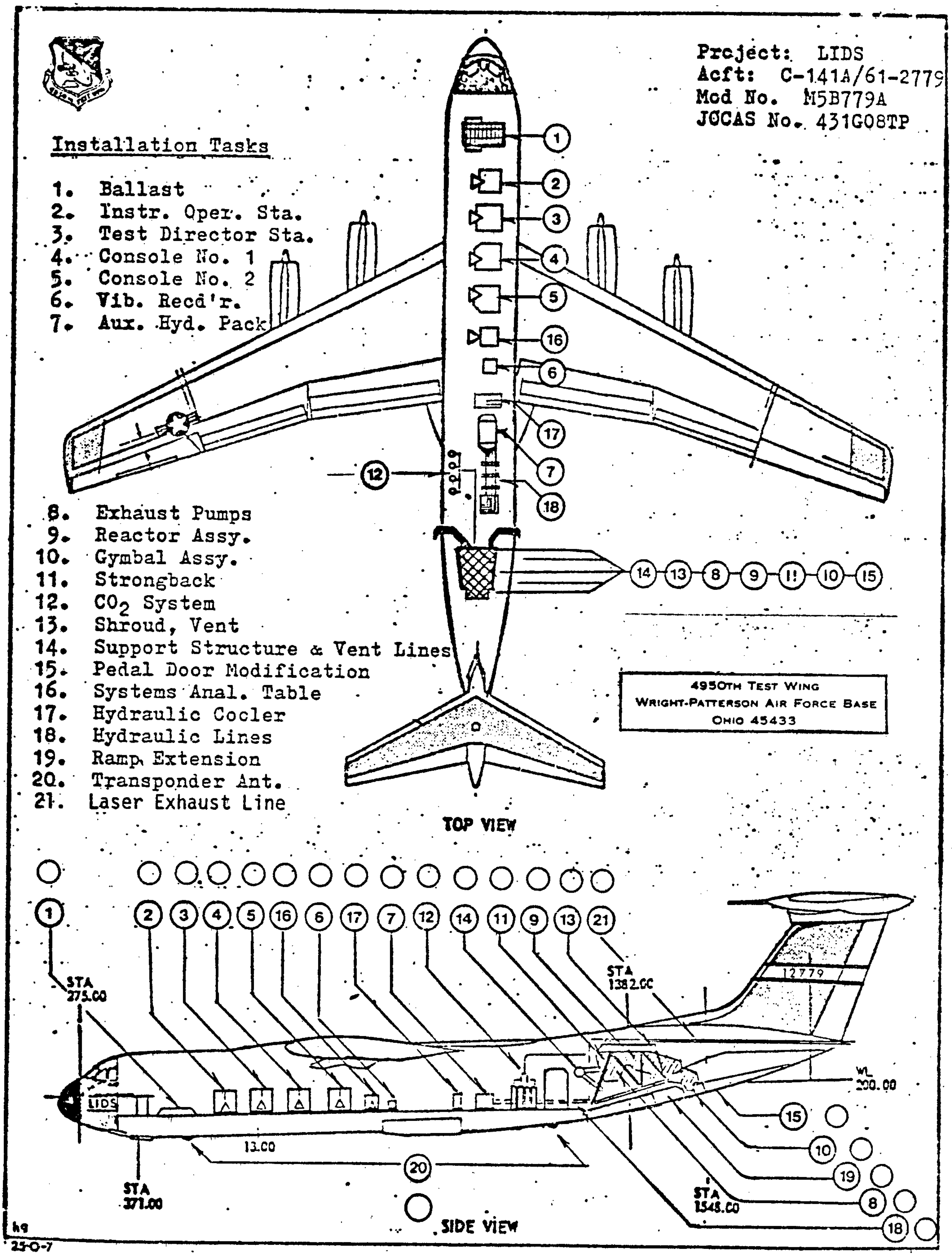


Figure 1. LIDS Profile Drawing

LASER REACTOR ASSEMBLY

HUGHES
HUGHES AIRCRAFT COMPANY

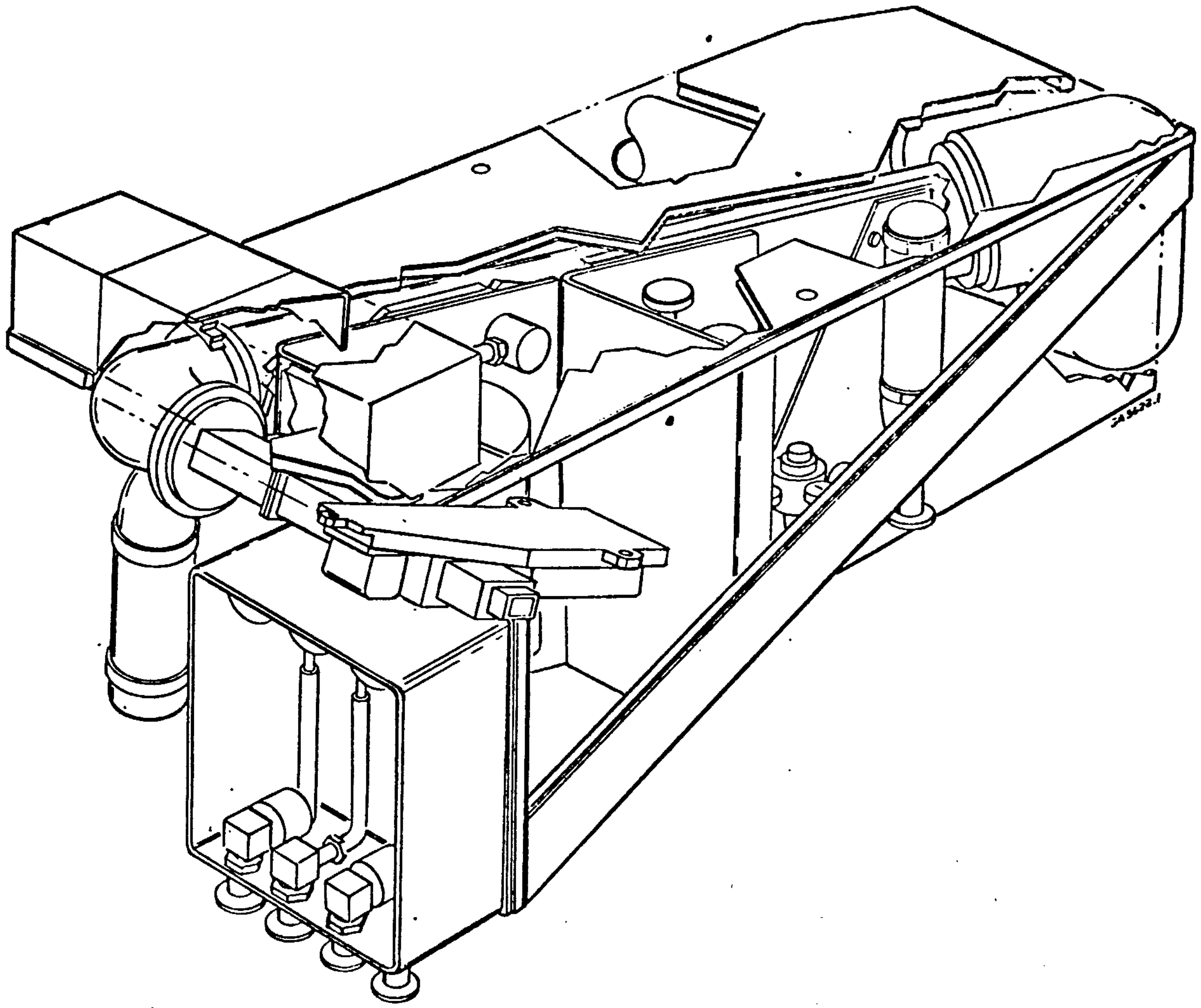


Figure 2. Laser Reactor Assembly

LASER EXHAUST ASSEMBLY

HUGHES

HUGHES AIRCRAFT COMPANY

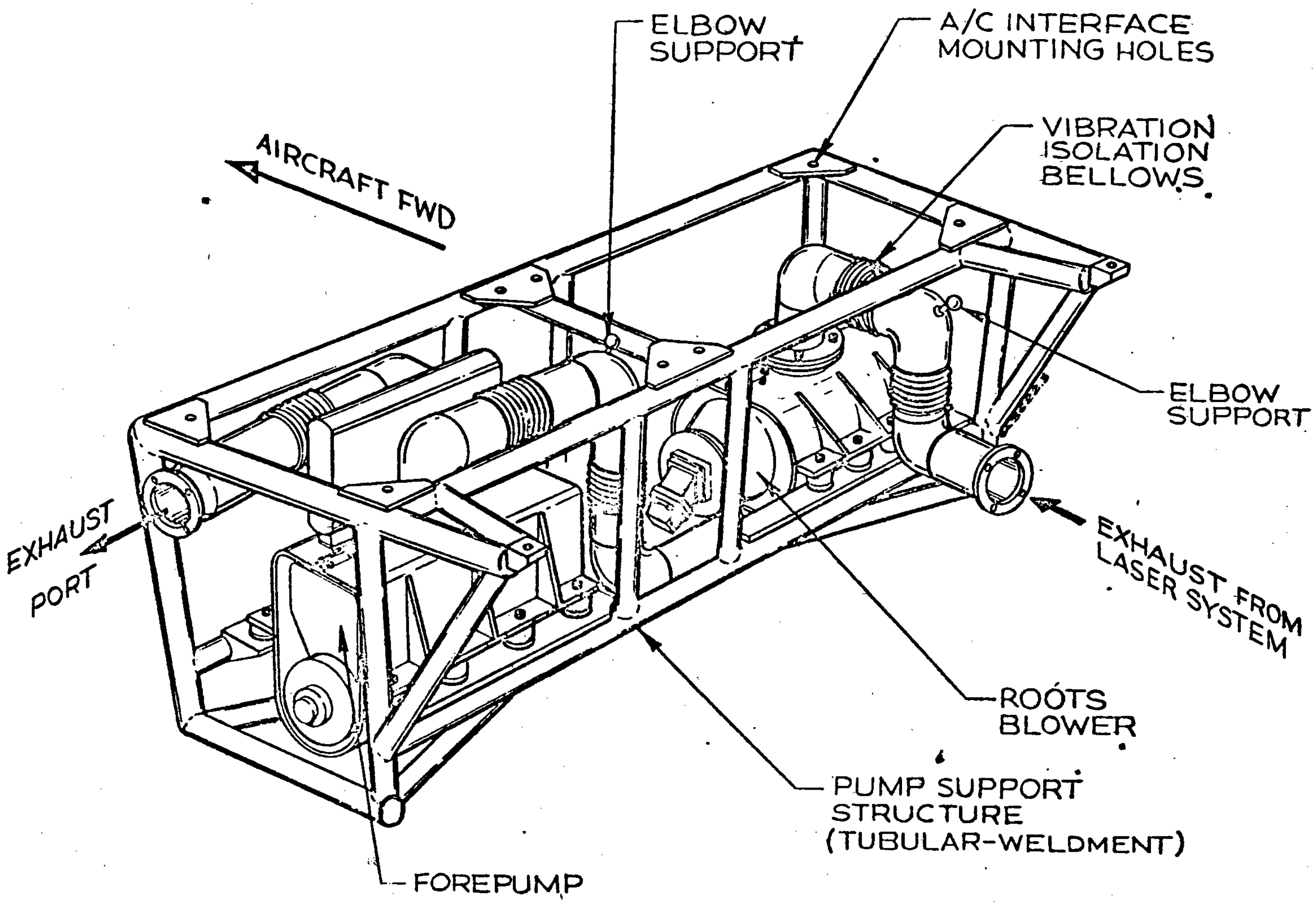


Figure 3. Laser Exhaust Assembly

LASER REACTOR SUPPORT STRUCTURE (U)

HUGHES
HUGHES AIRCRAFT COMPANY

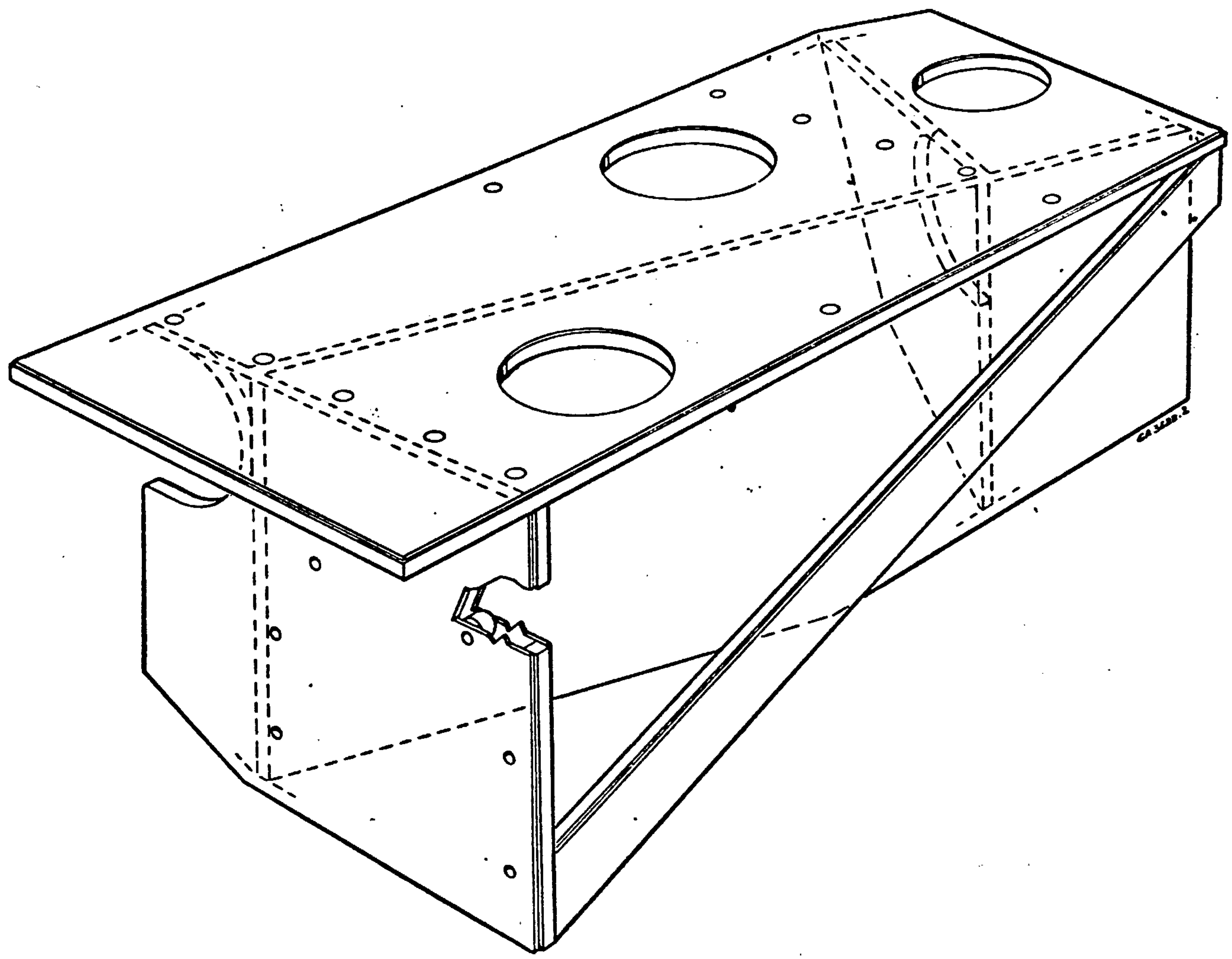


Figure 4. Laser Reactor Support Structure

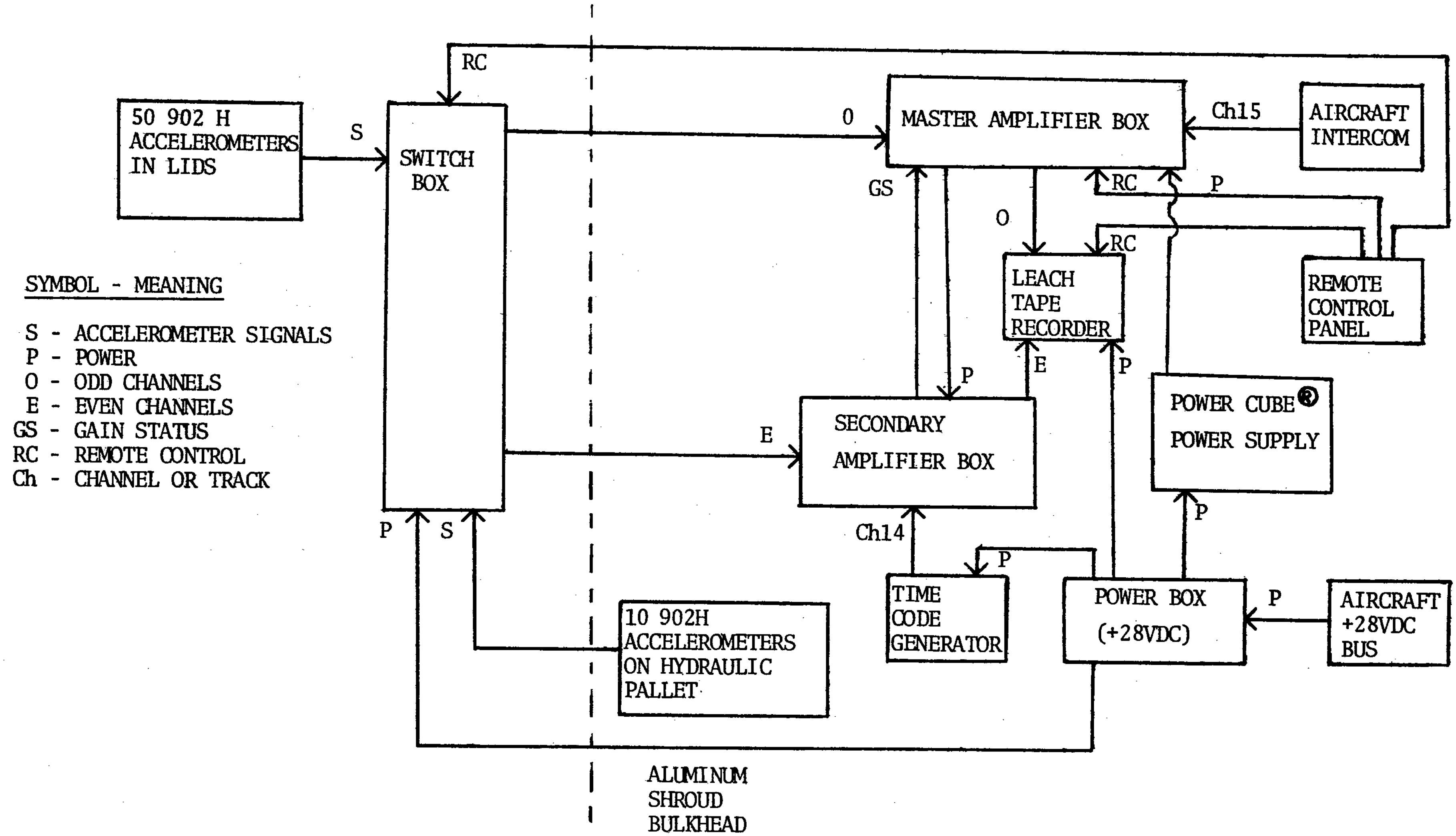
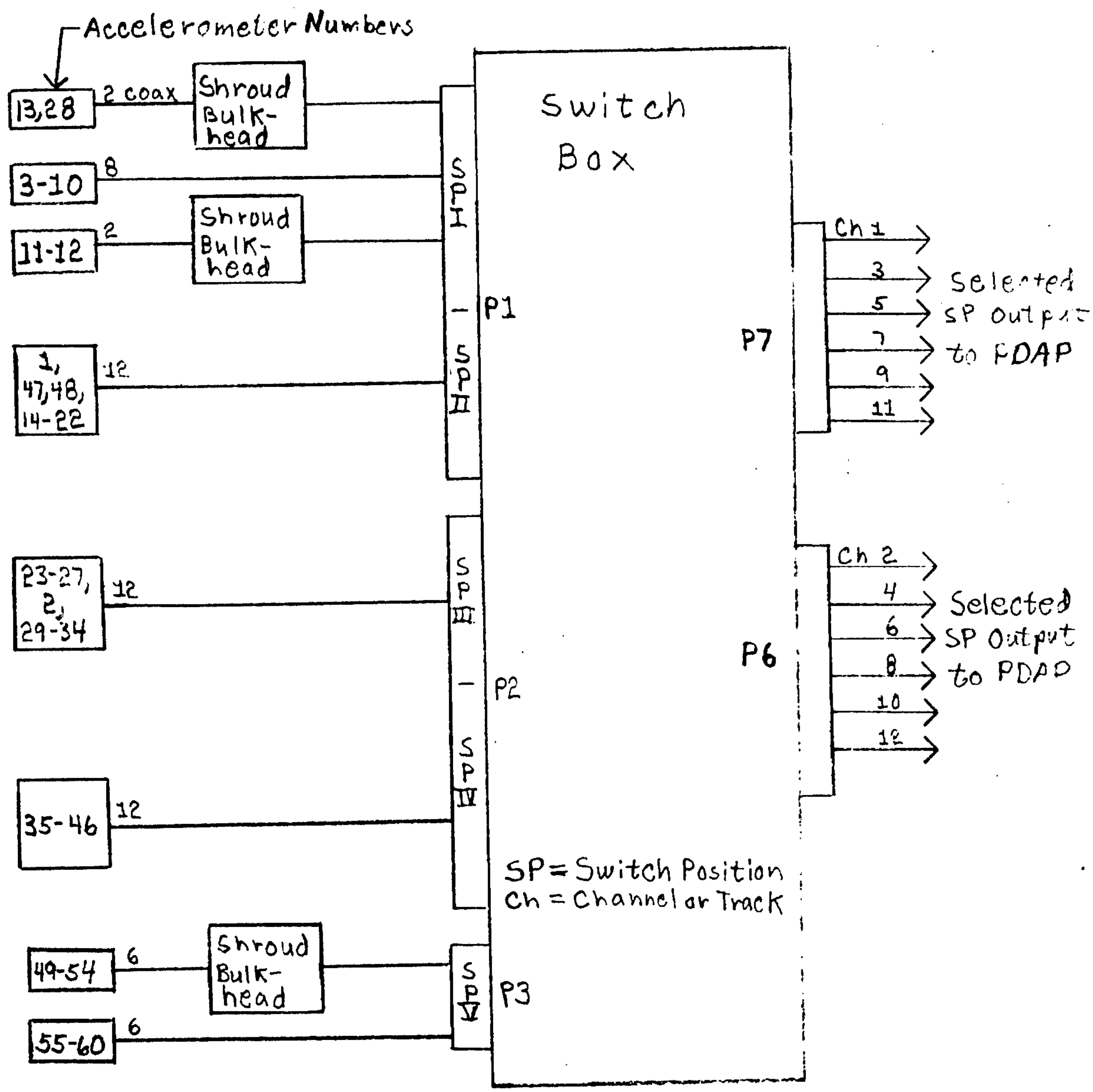


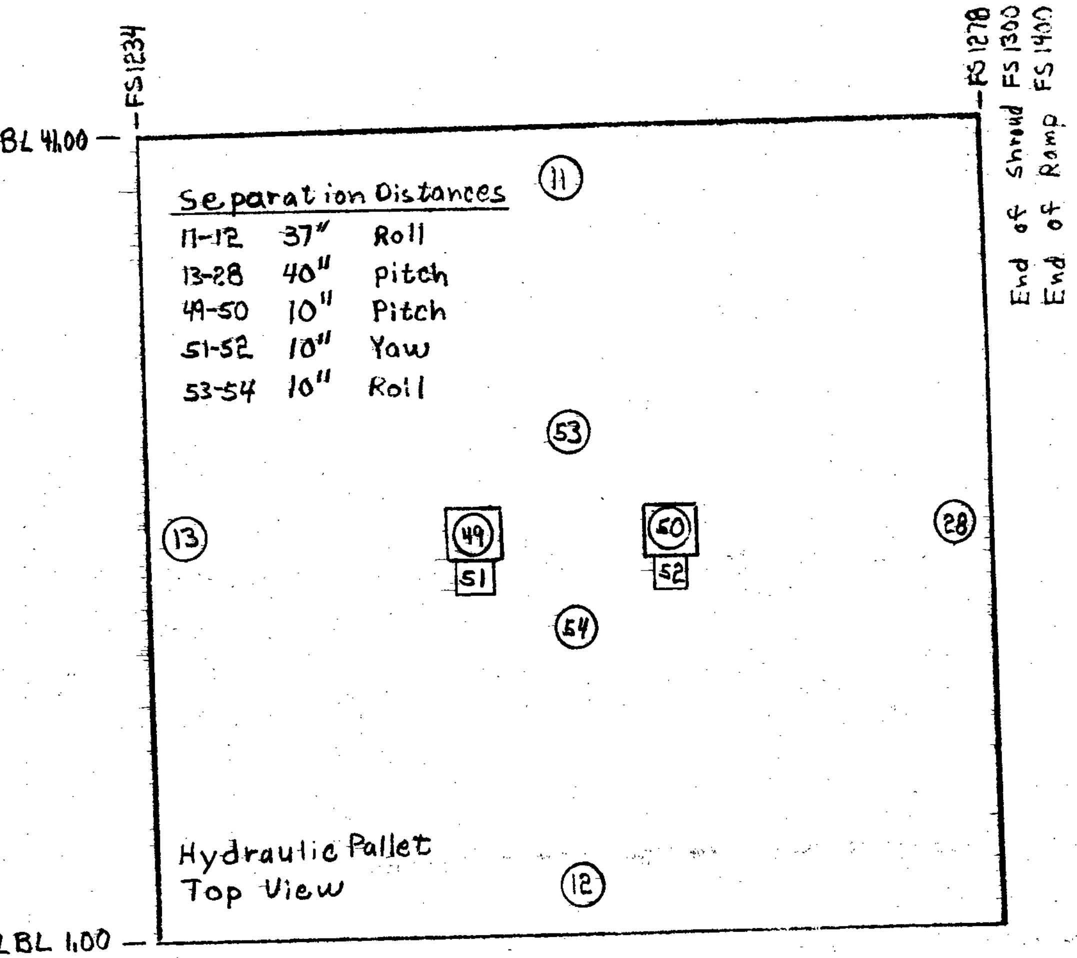
Figure 5. Instrumentation Block Diagram for C-141 Laser Flight Test



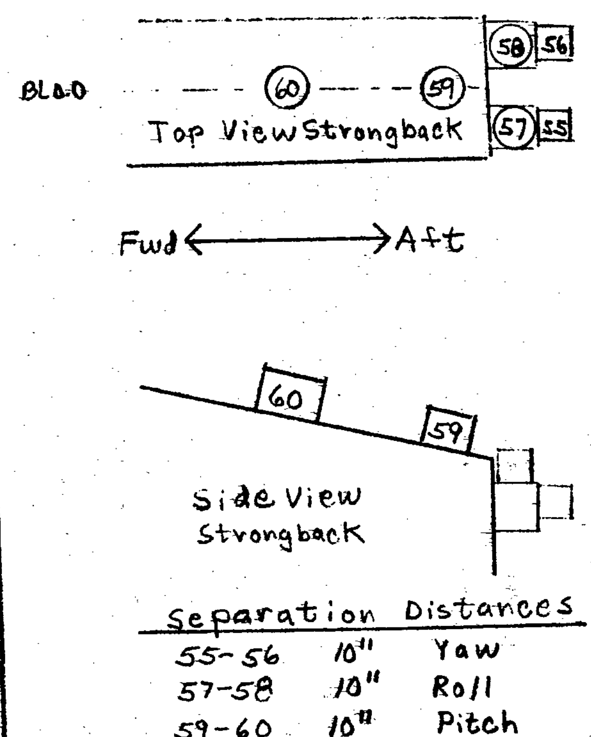
Note: Wires between each Accelerometer microdot connector and Switch Box are all microdot coax.

ACCEL. #/Chan./SP TABLE													
Chan No.		1	2	3	4	5	6	7	8	9	10	11	12
SWITCH POSITION (SP)	I	13	28	3	4	5	6	7	8	9	10	11	12
	II	1	47	48	14	15	16	17	18	19	20	21	22
	III	23	24	25	26	27	2	29	30	31	32	33	34
	IV	35	36	37	38	39	40	41	42	43	44	45	46
	V	49	50	51	52	53	54	55	56	57	58	59	60

Figure 6. Mapping Between Accelerometer Numbers and Switch Position Numbers.



Accelerometers on Hydraulic Pallet on the Cargo Deck



Sketch of Accelerometers on Top of Strongback just above turret

Figure 7. Location of Linear Accelerometers for Obtaining Angular Data

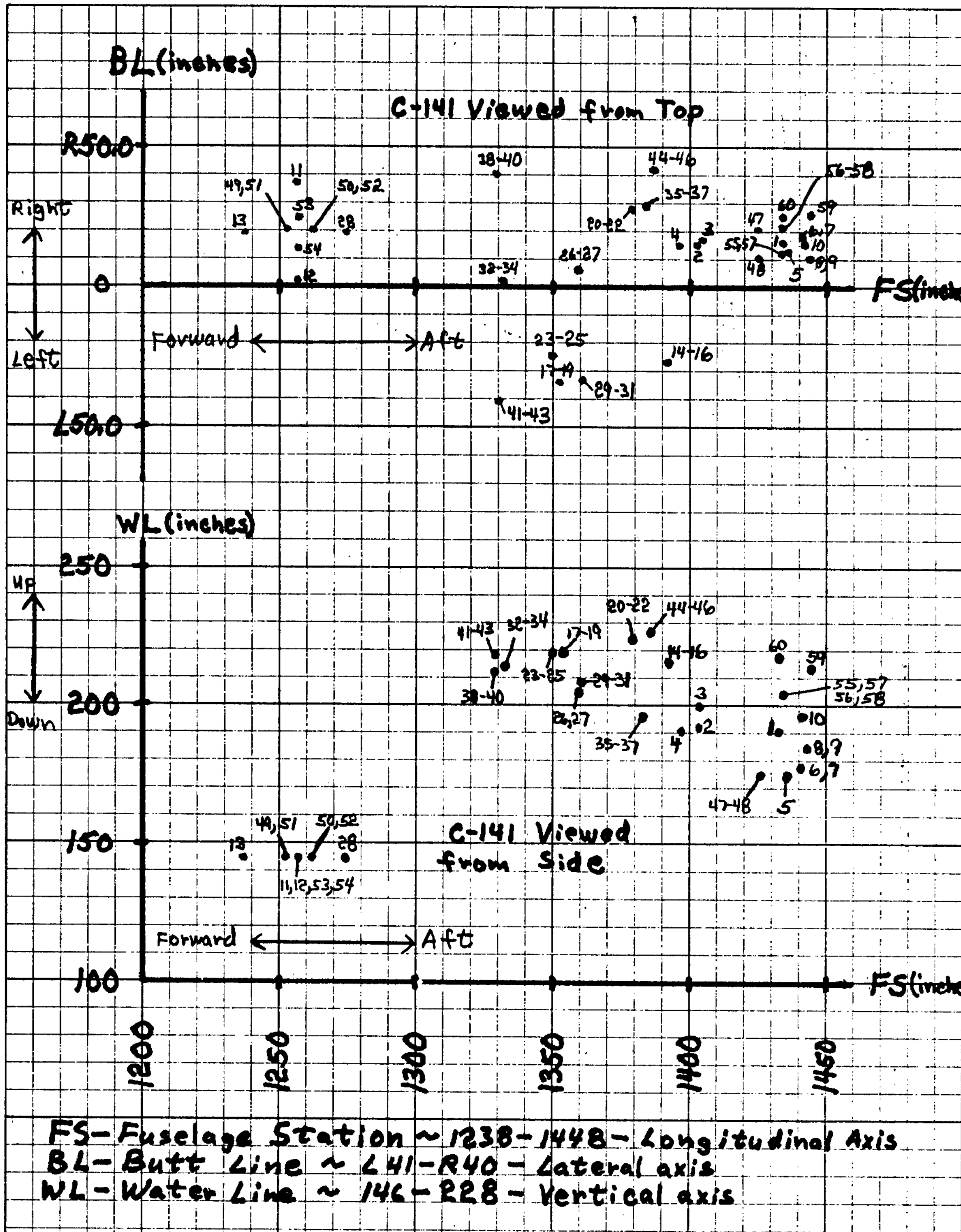


Figure 8. Plot of Accelerometer Locations Versus C-141 Axes

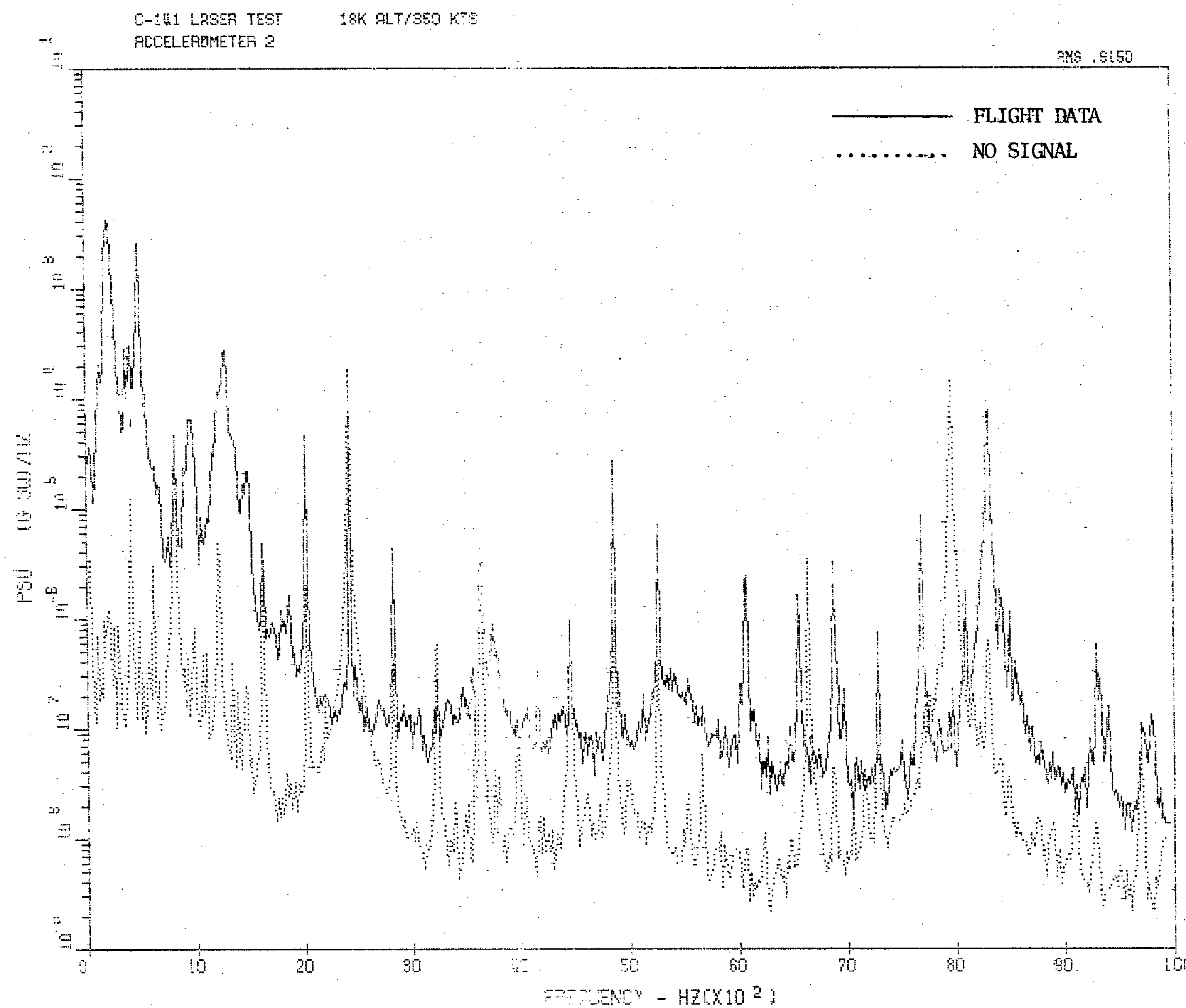


Figure 9. Typical 10kHz PSDs of Flight Data and No Signal Data

10
41

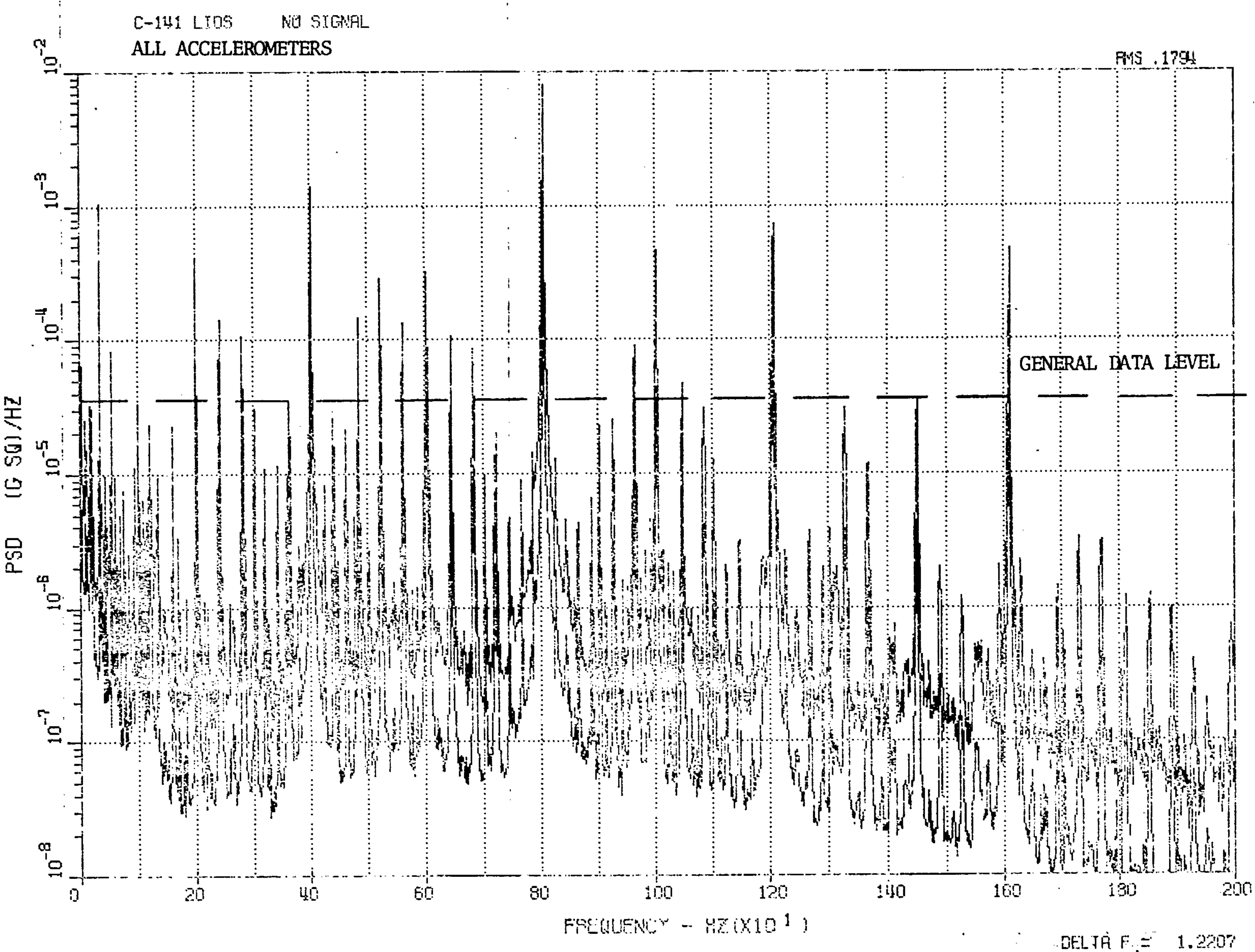


Figure 10. Maximum and Average PSDs for all Accelerometers - No Signal Case

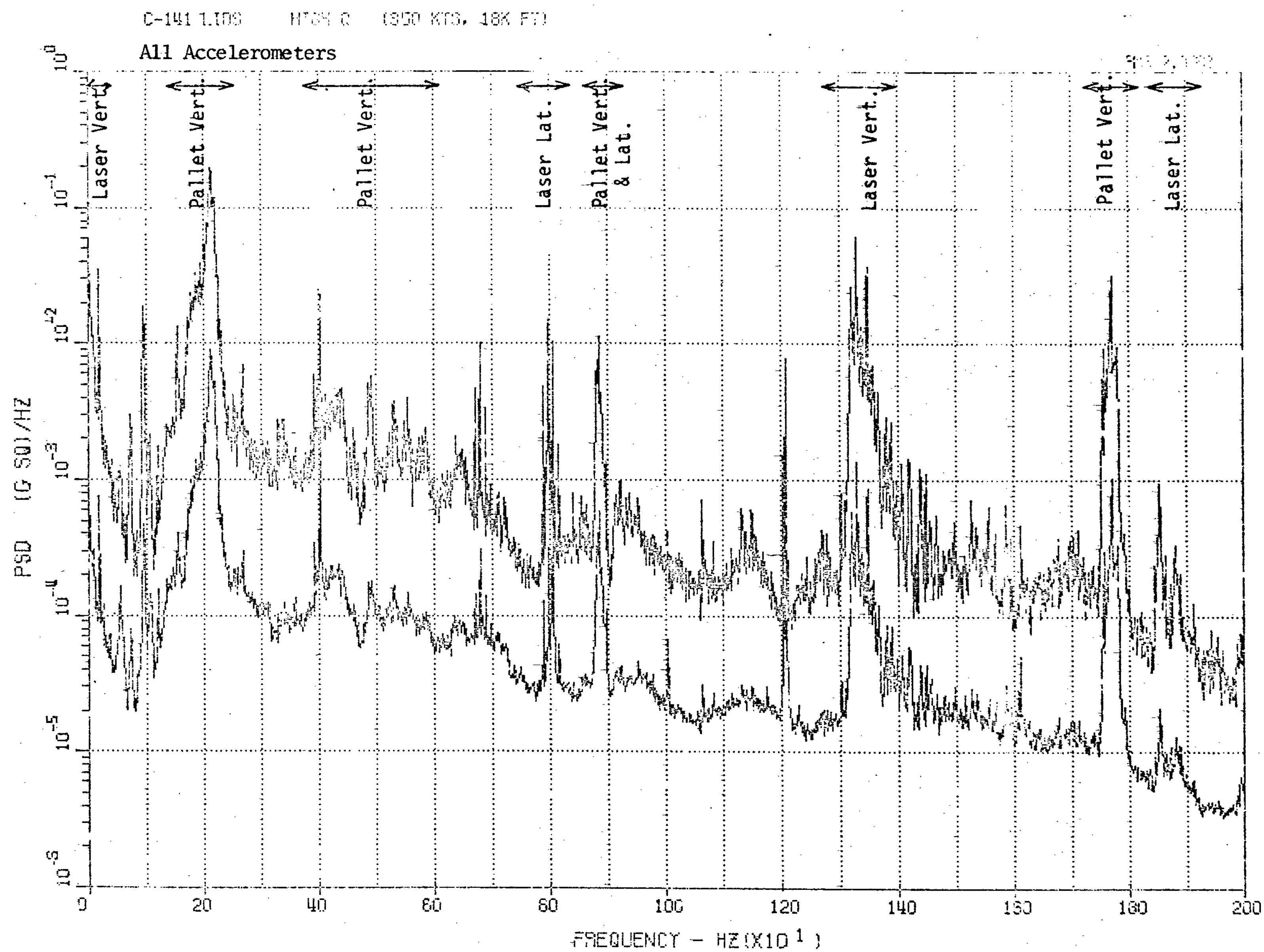


Figure 11. Maximum and Average PSDs for all Accelerometers - 350 KTS, 18K Ft

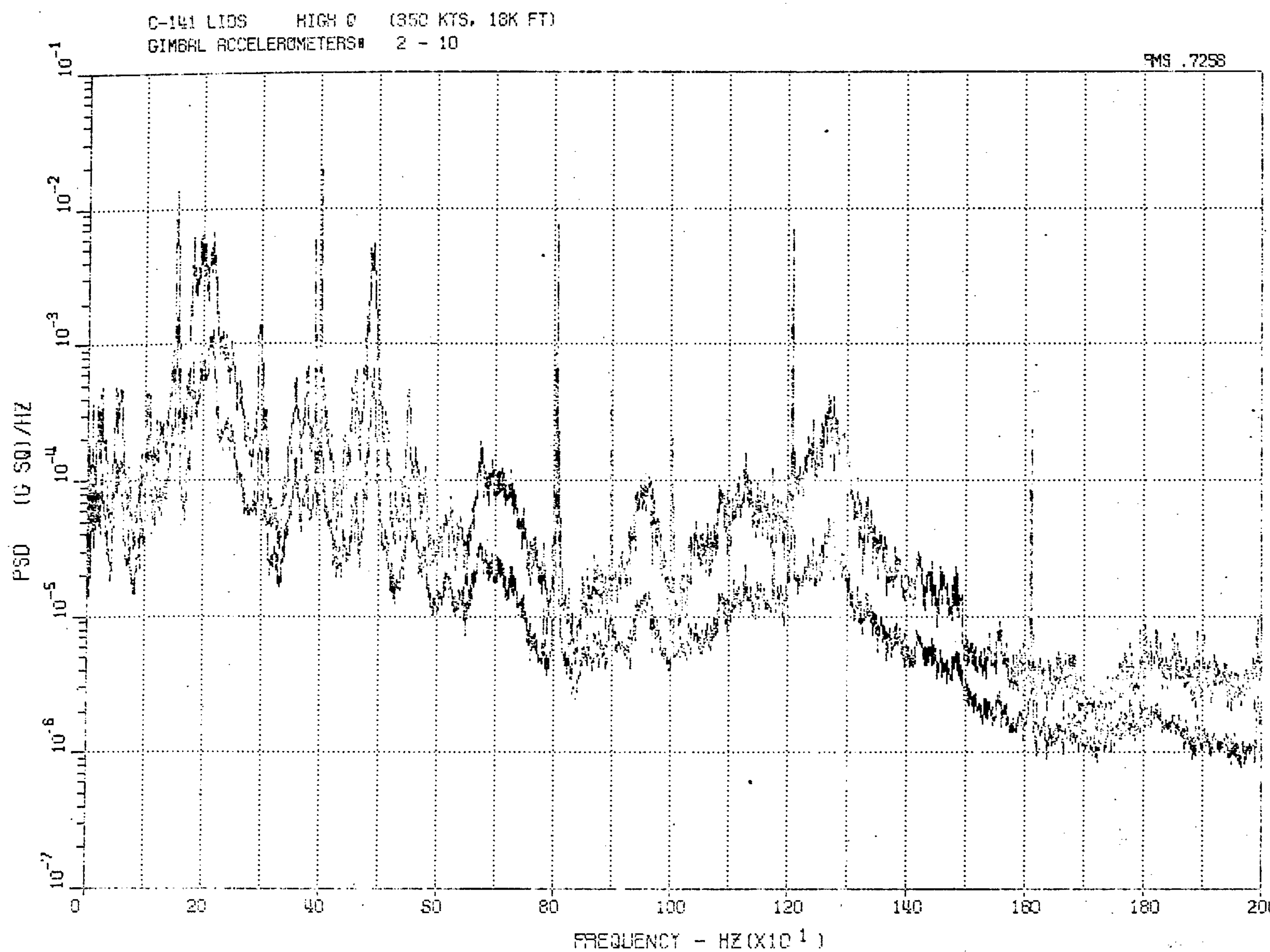


Figure 12. Maximum and Average PSDs for Gimbal Accelerometers - 350 KTS, 18K Ft

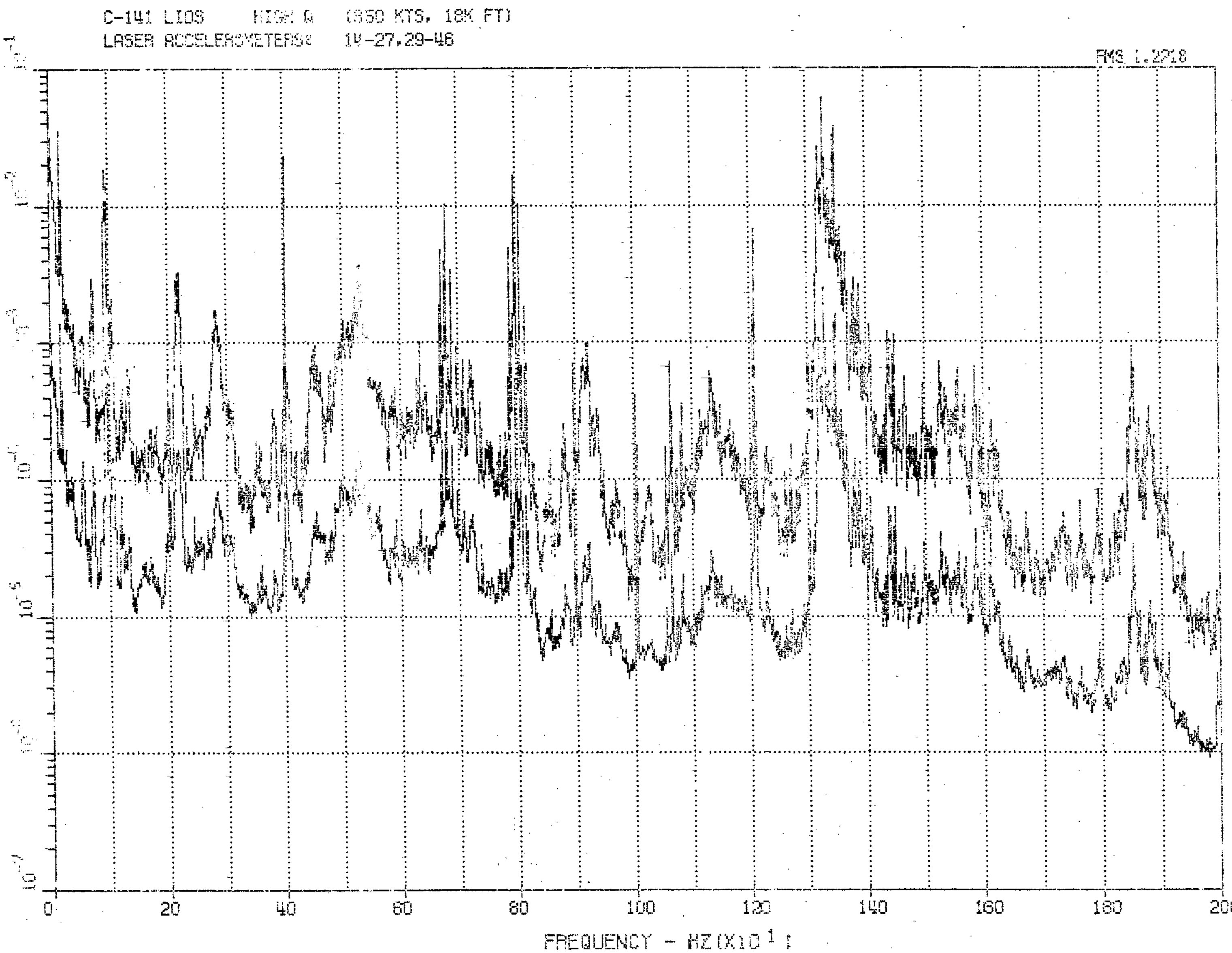


Figure 13. Maximum and Average PSDs for Laser Accelerometers - 350 KTS, 18K Ft

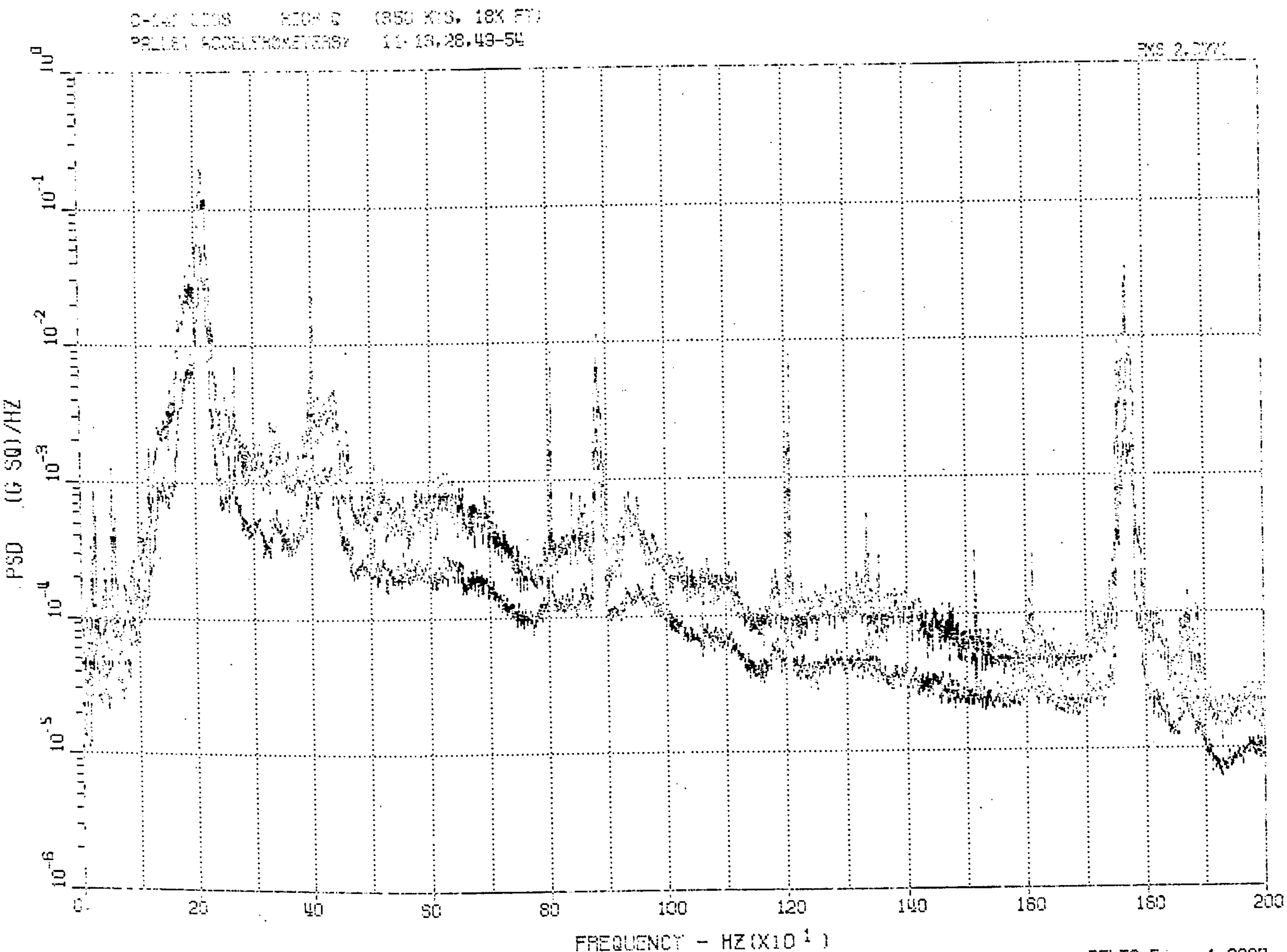


Figure 14, Maximum and Average PSDs for Pallet Accelerometers - 350 KTS, 18K Ft

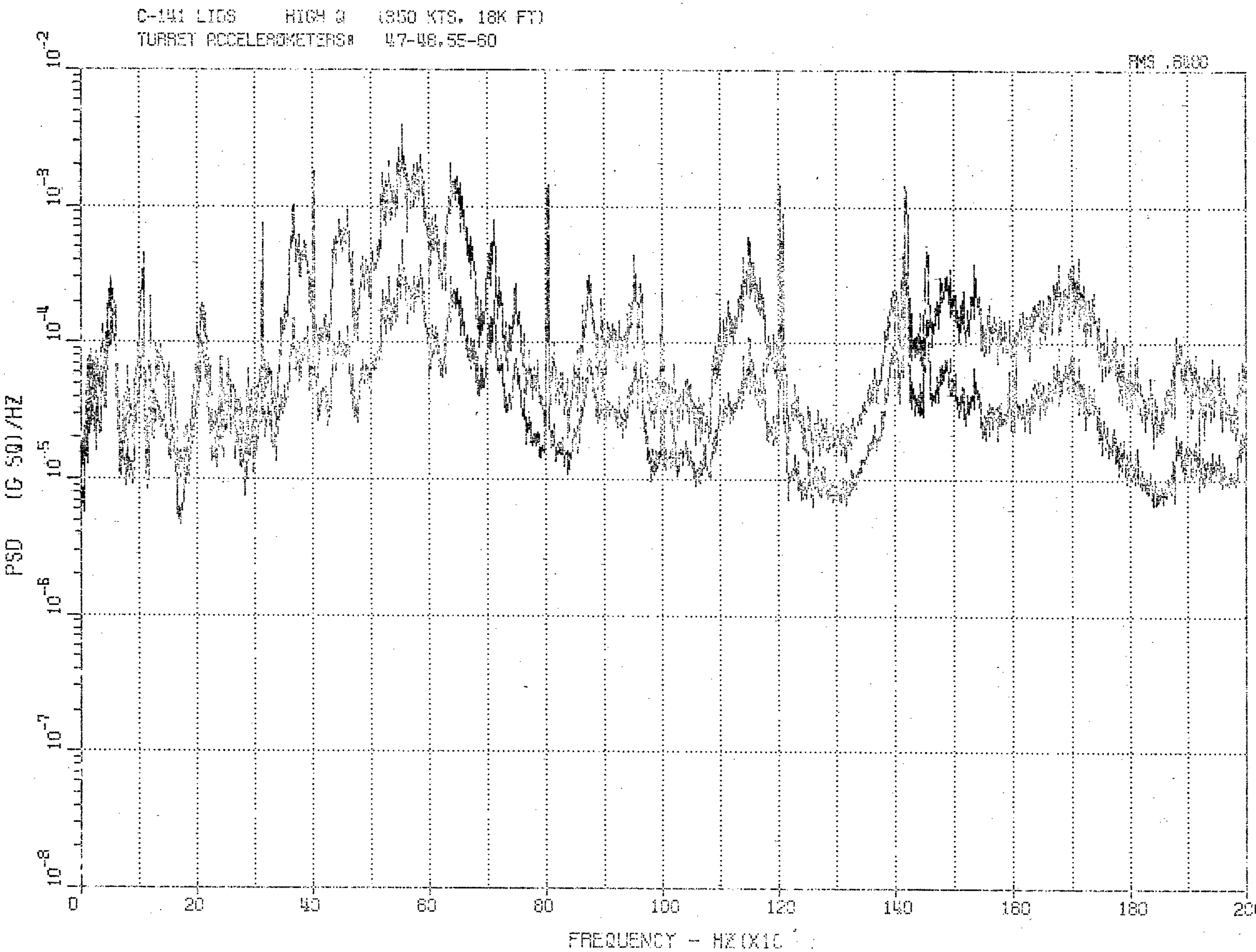


Figure 15. Maximum and Average PSDs for Turret Accelerometers - 350 KTS, 18K Ft

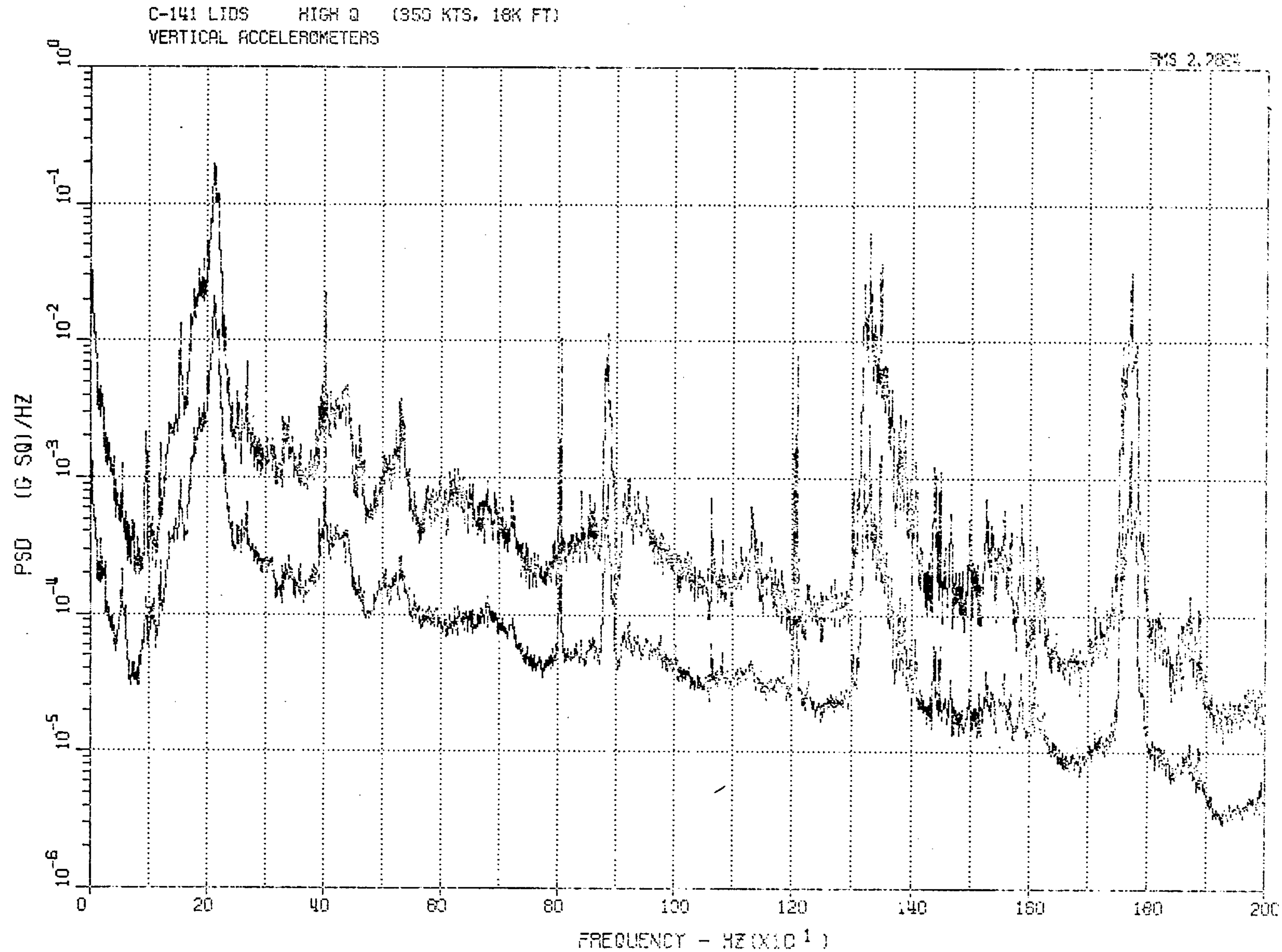


Figure 16. Maximum and Average PSDs for Vertical Accelerometers - 350 KTS, 18K Ft

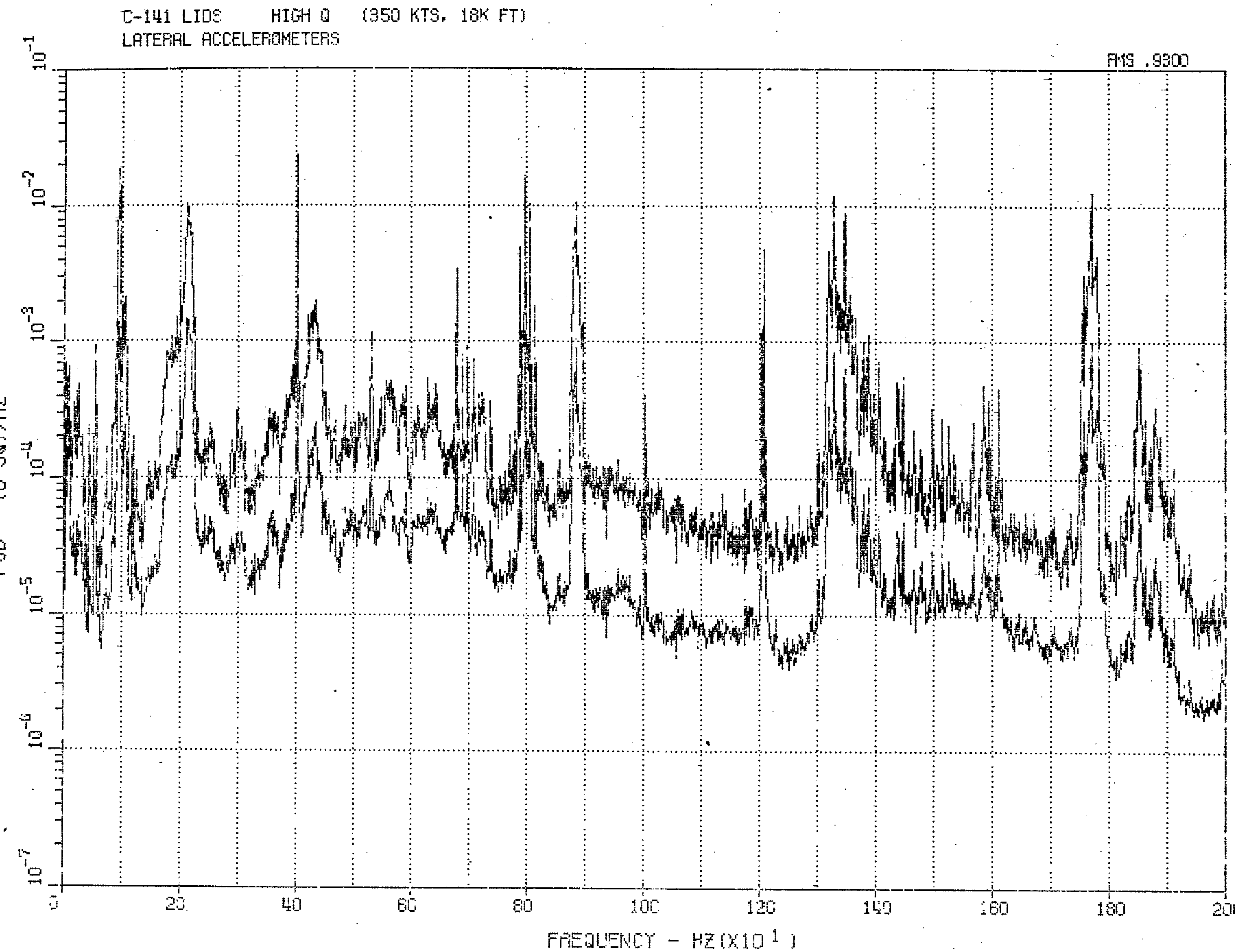


Figure 17. Maximum and Average PSDs for Lateral Accelerometers - 350 KTS, 18K Ft

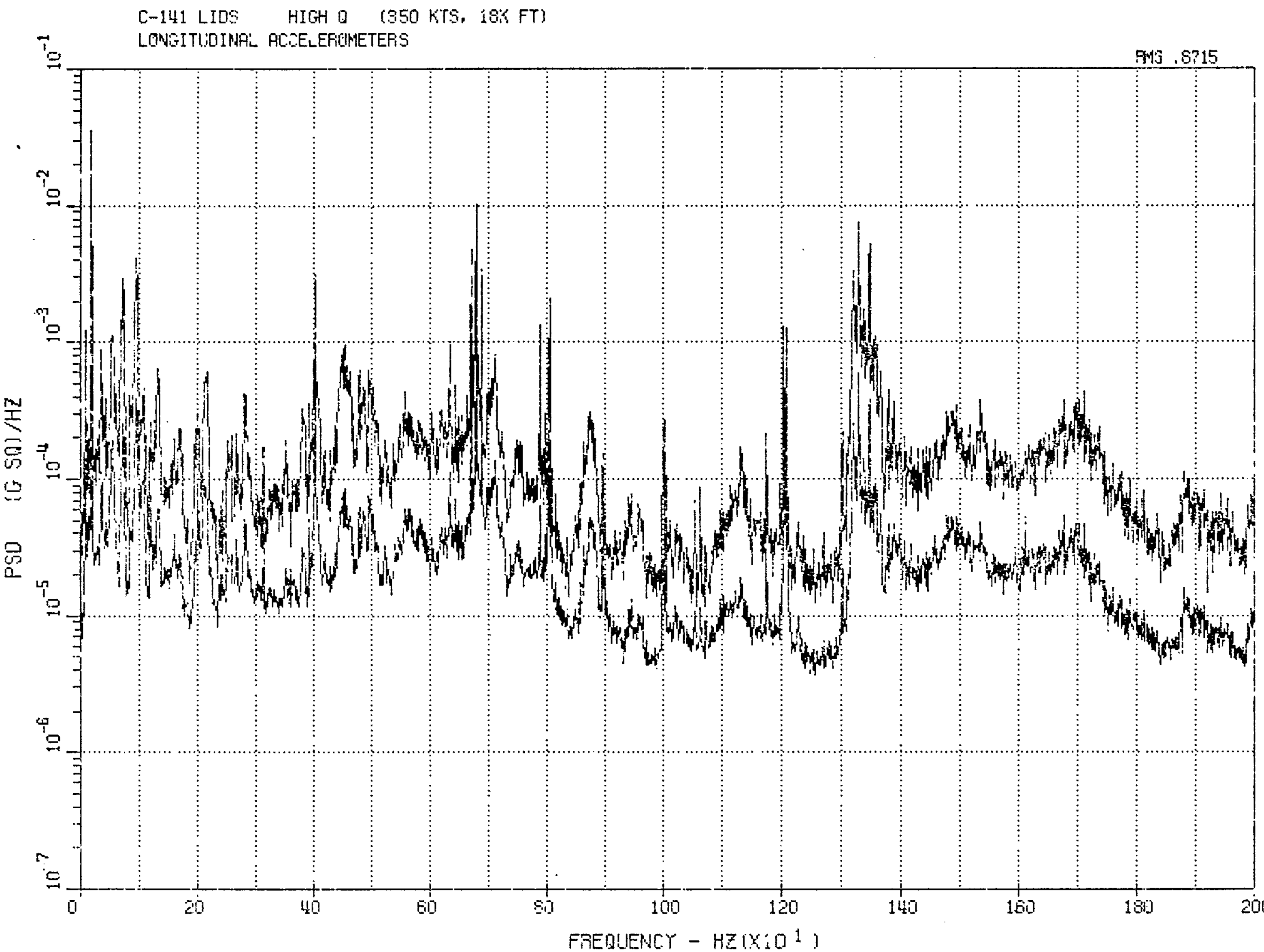


Figure 18. Maximum and Average PSDs for Longitudinal Accelerometers - 350 KTS, 18K Ft

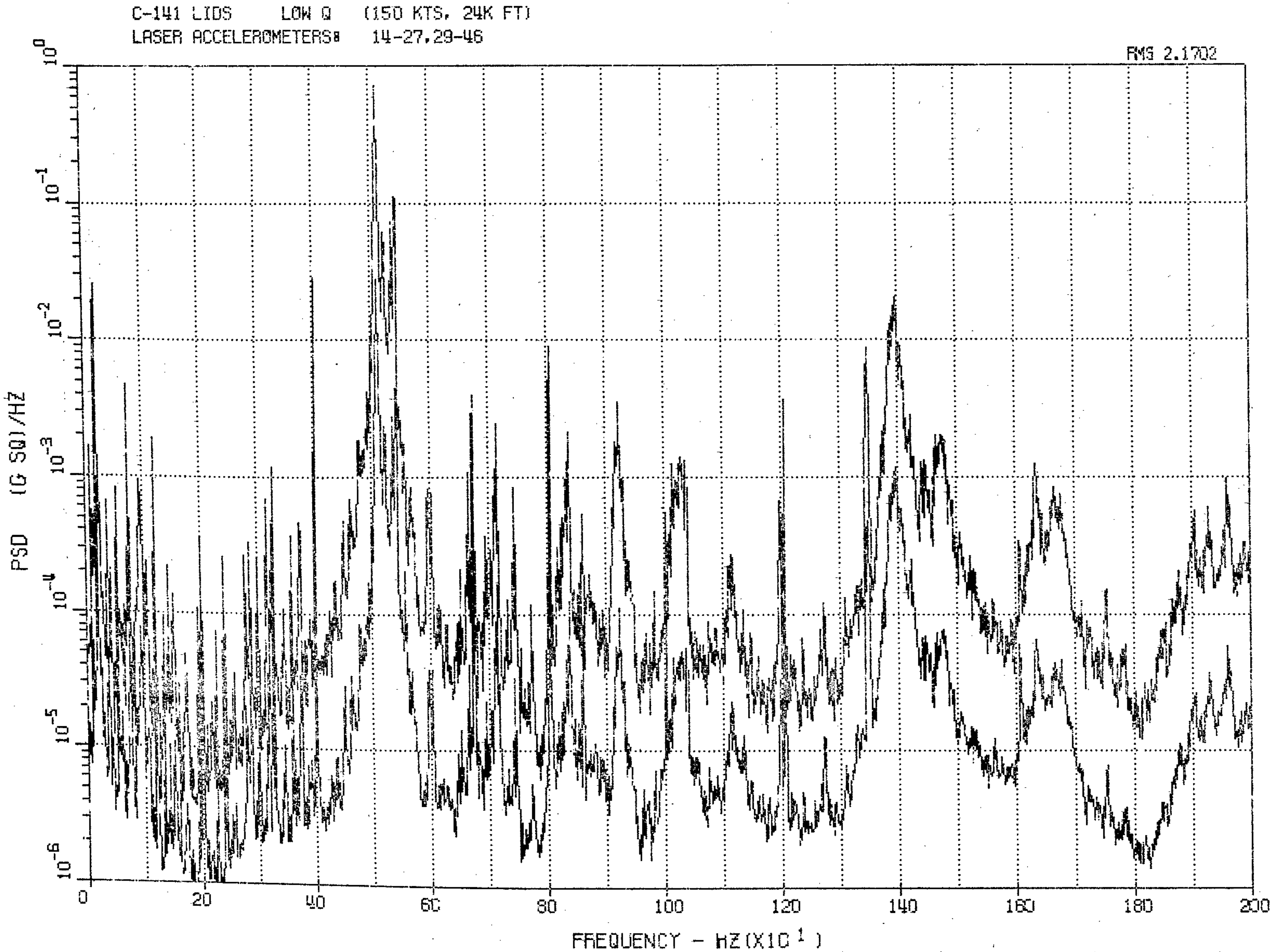


Figure 19. Maximum and Average PSDs for Laser Accelerometers - 150 KTS, 24K Ft

4
4950

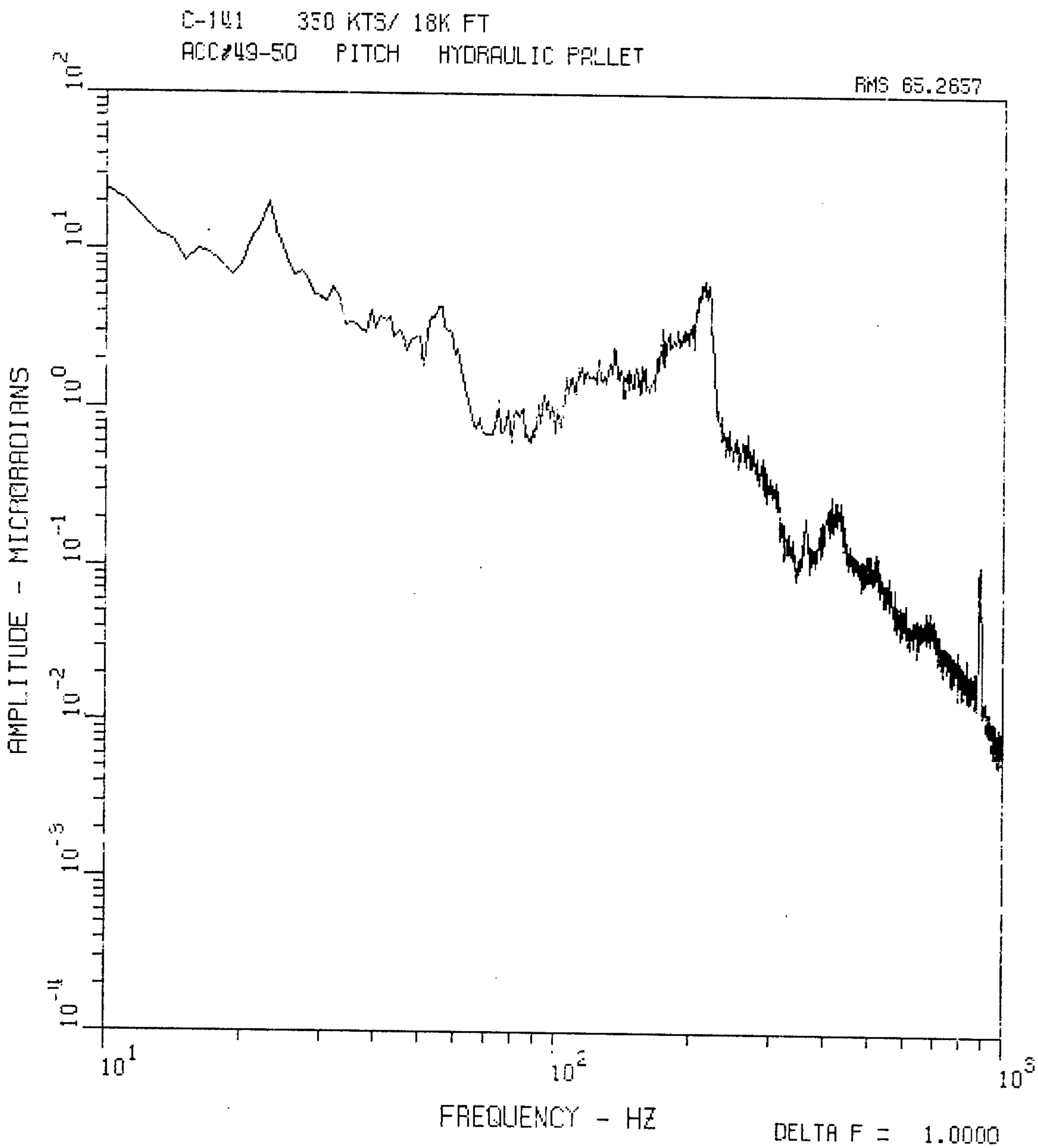


Figure 20. Amplitude Spectrum of Angular Vibration about Pitch Axis Derived from Accel. #49, 50

6
5354

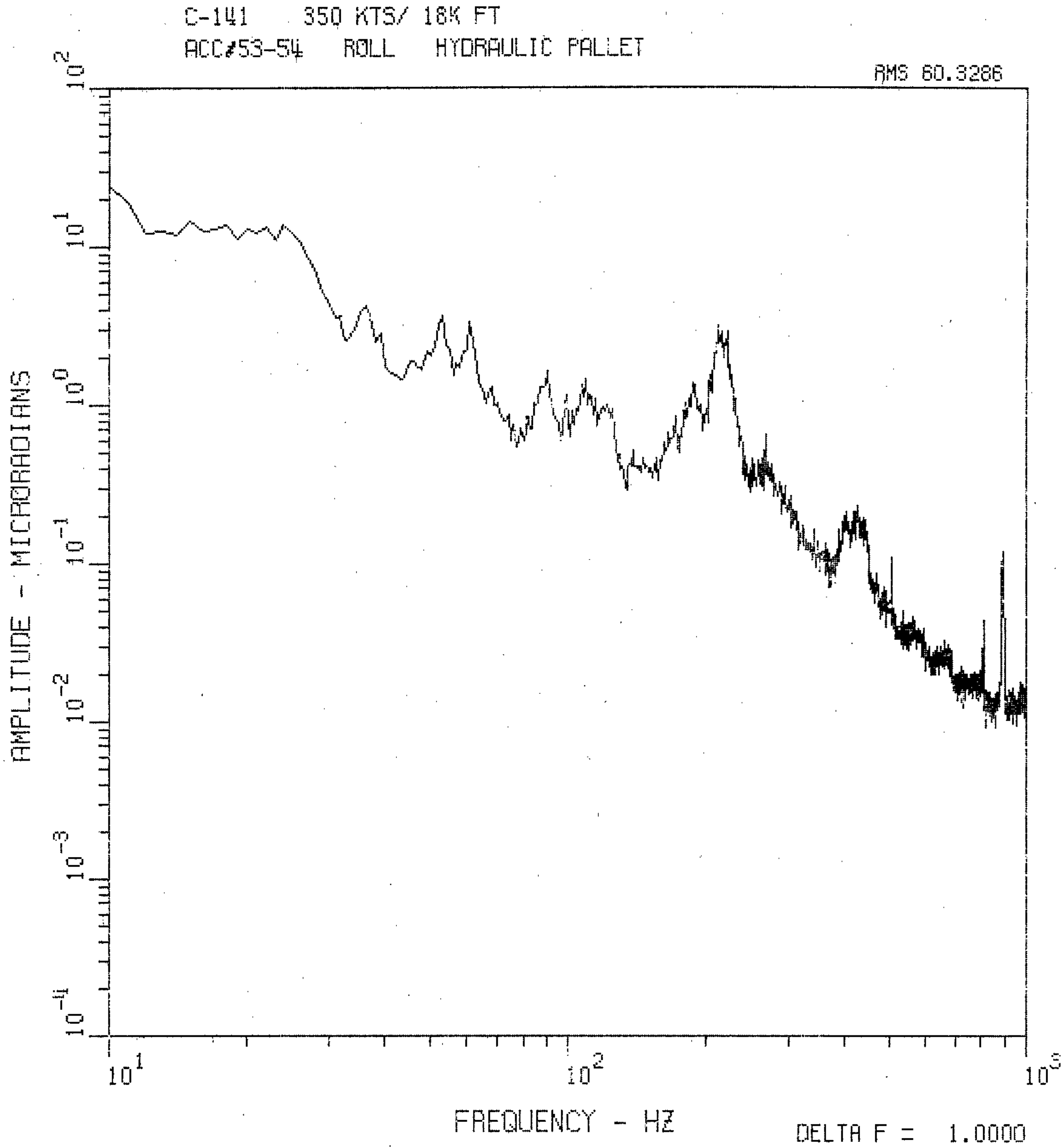


Figure 21. Amplitude Spectrum of Angular Vibration about Roll Axis Derived from Accel. #53, 54

5
5152

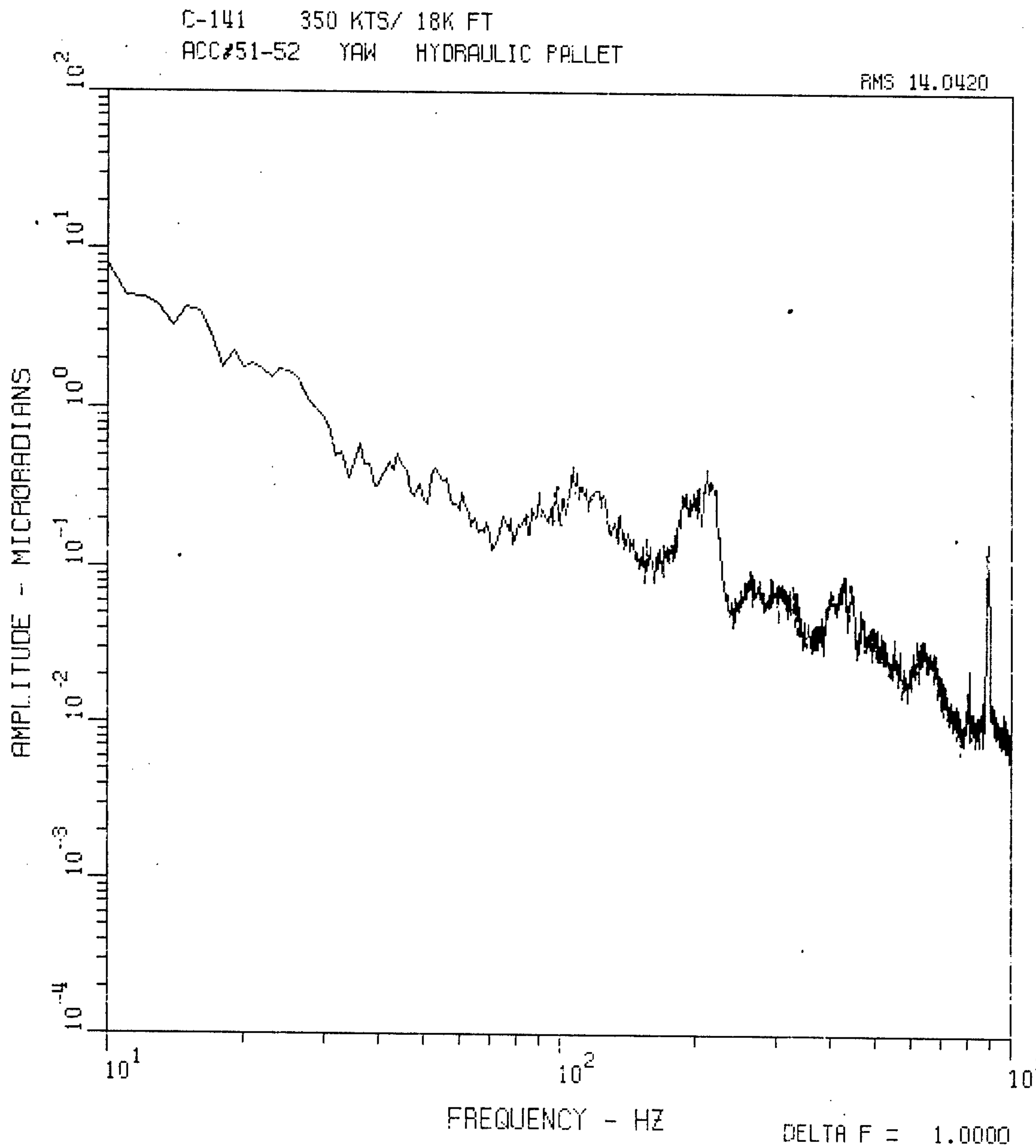


Figure 22. Amplitude Spectrum of Angular Vibration about Yaw Axis Derived from Accel. #51, 52

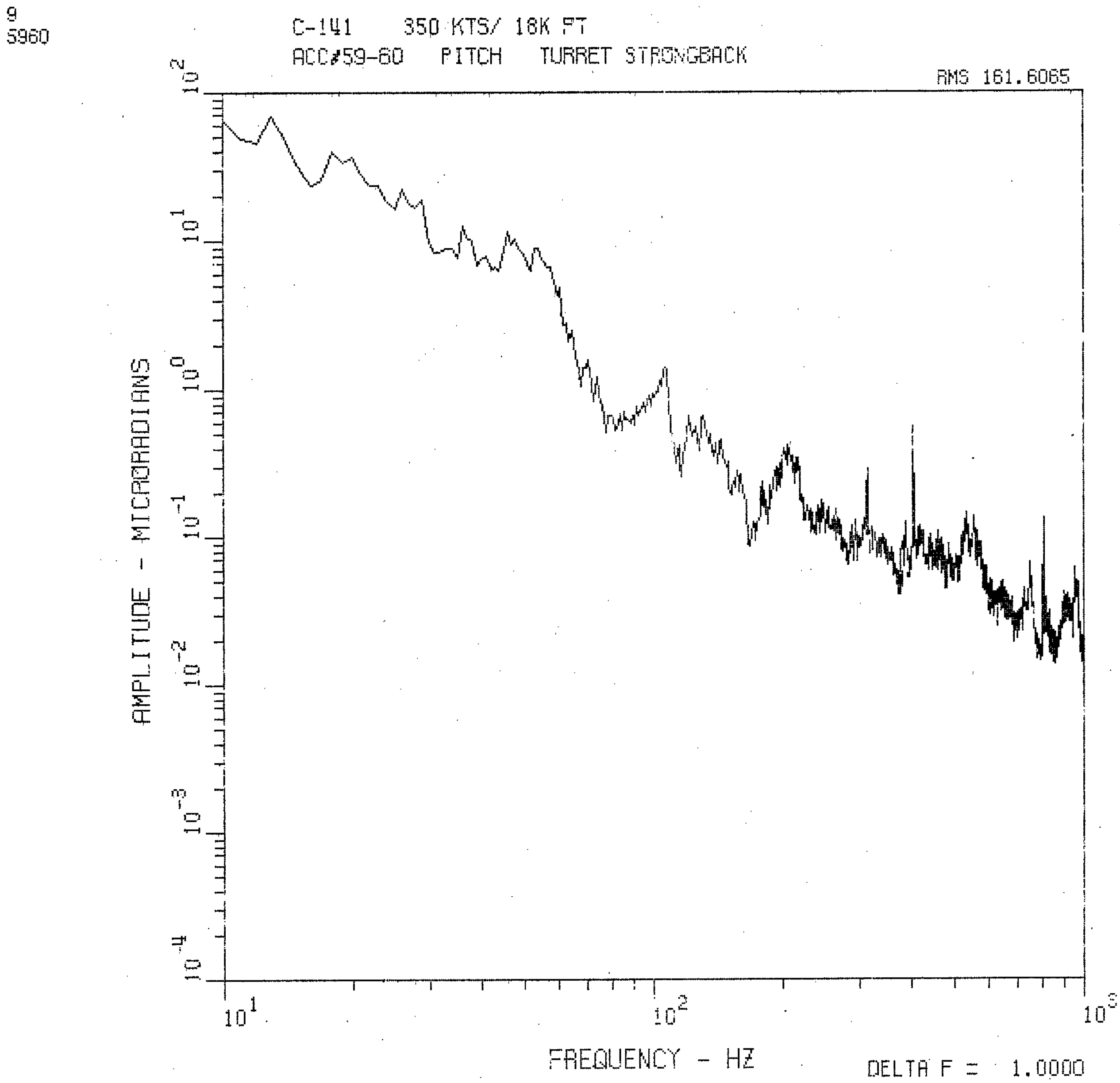


Figure 23. Amplitude Spectrum of Angular Vibration about Pitch Axis Derived from Accel. #59, 60

8
5758

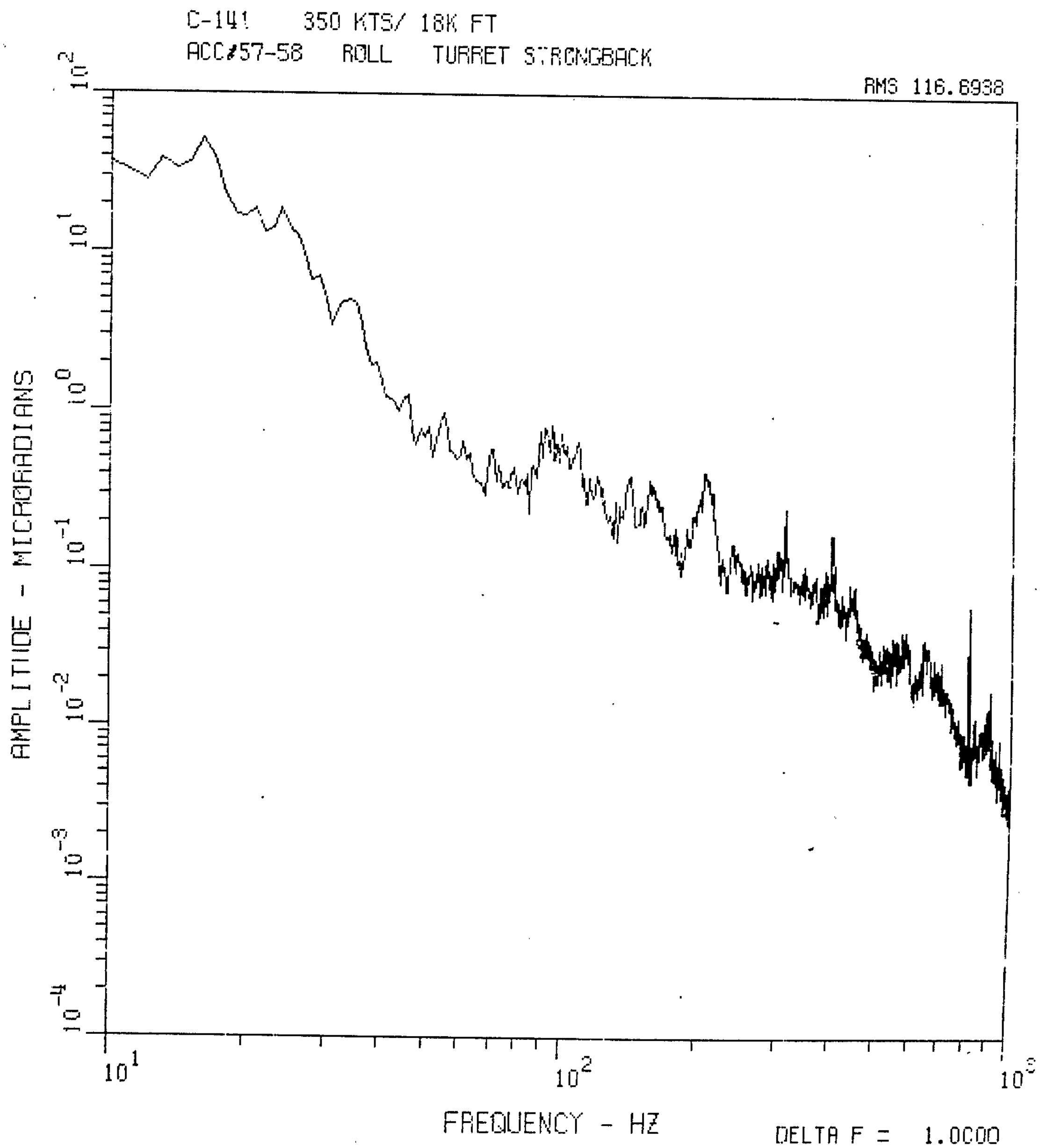


Figure 24. Amplitude Spectrum of Angular Vibration about Roll Axis Derived from Accel. #57, 58

7
5556

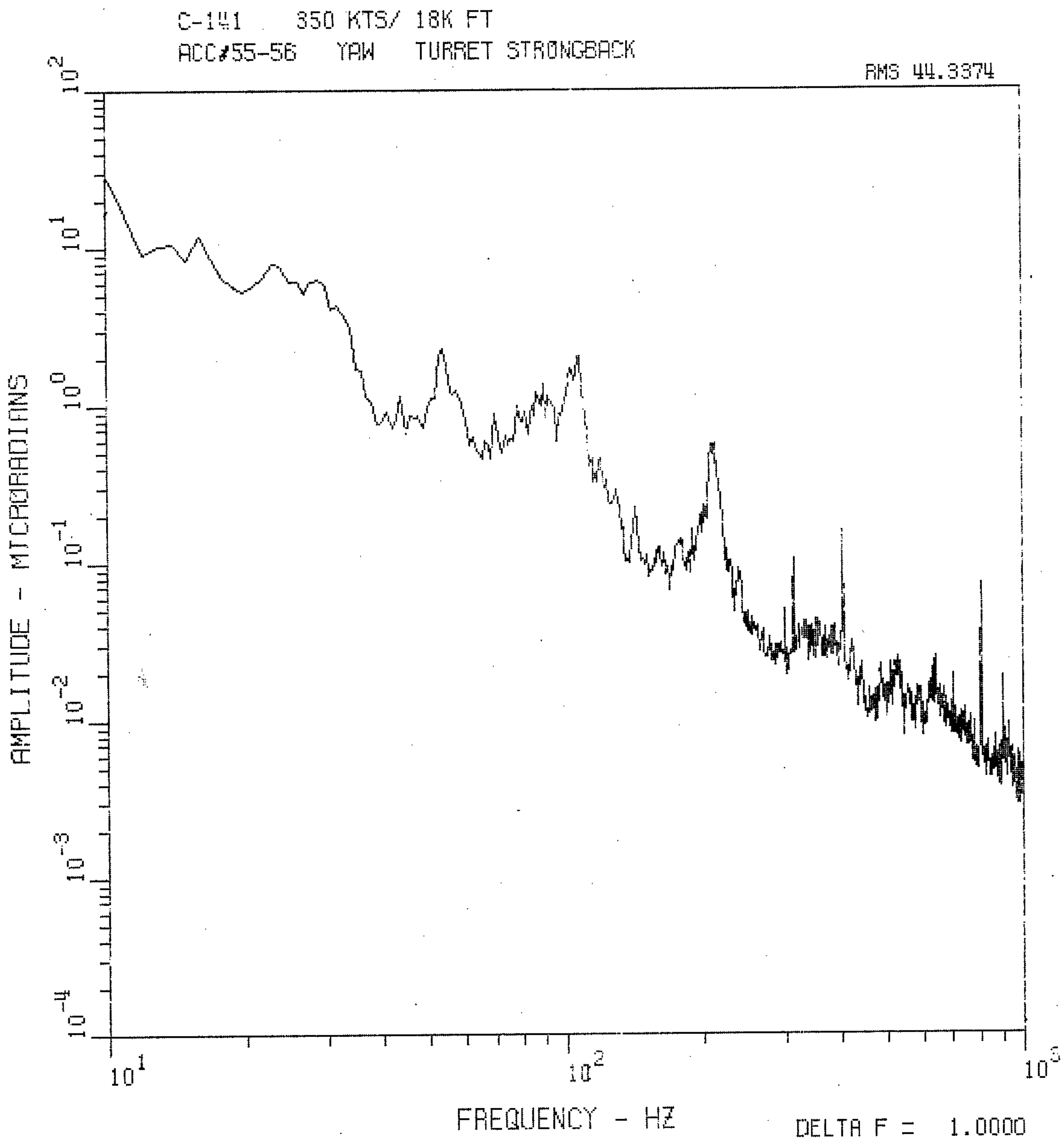


Figure 25. Amplitude Spectrum of Angular Vibration about Yaw Axis Derived from Accel. #55, 56

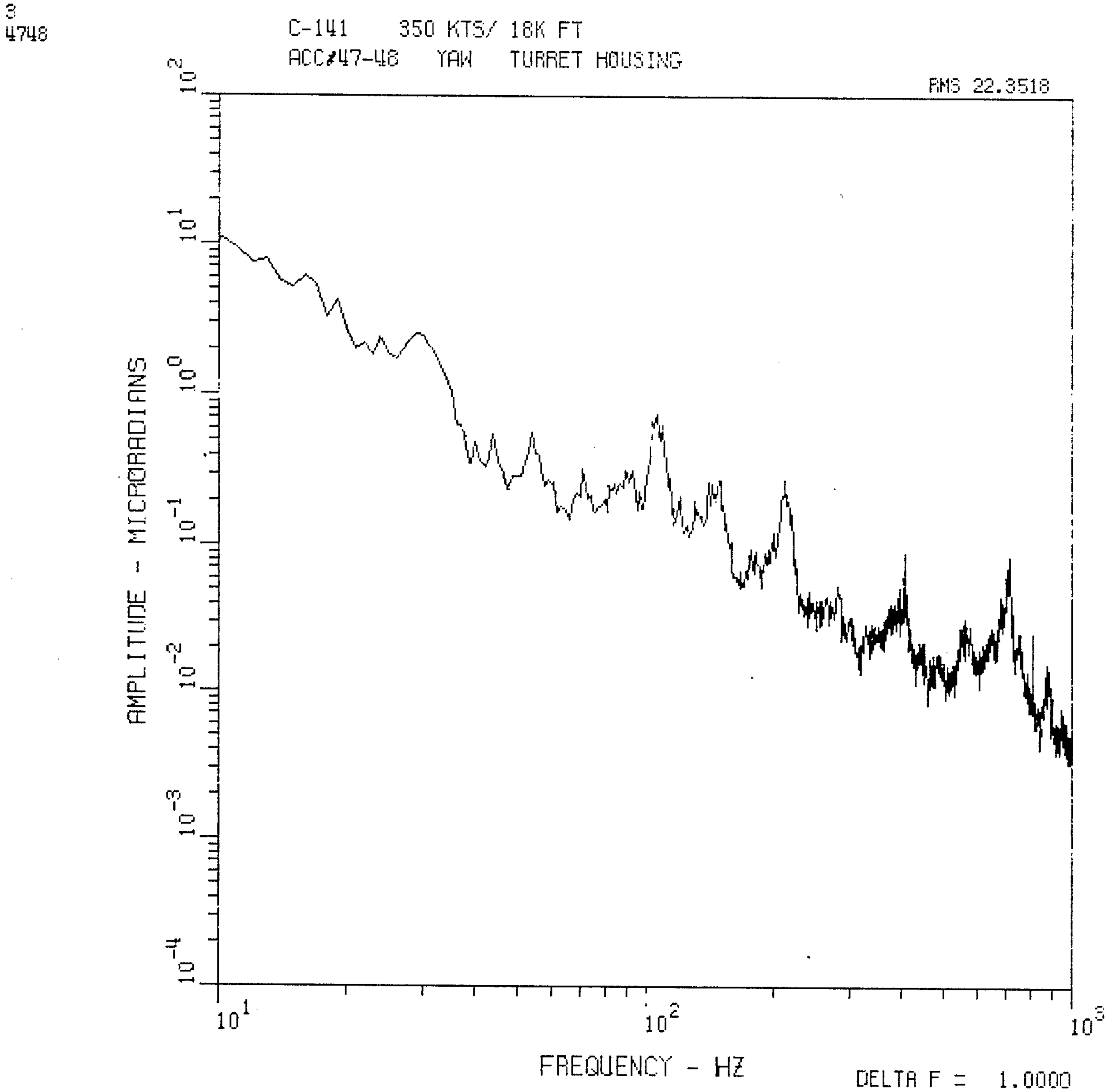


Figure 26. Amplitude Spectrum of Angular Vibration about Yaw Axis Derived from Accel. #47, 48

APPENDIX D

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27	Accelerometer 54 on Hydraulic Pallet	72
28	Accelerometers 55-58 on Top of Strongback Just Above Turret	73
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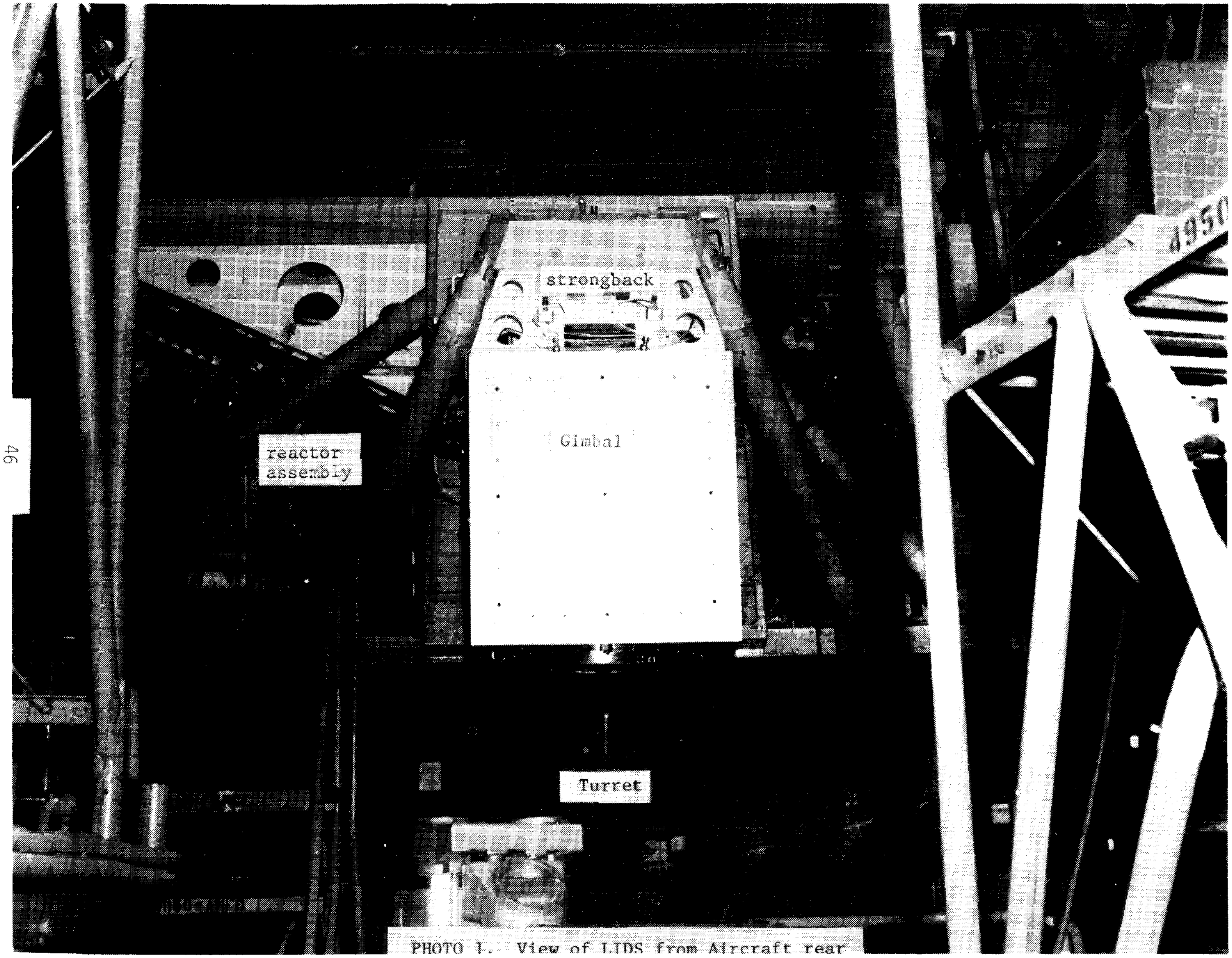


PHOTO 1. View of LIDS from Aircraft rear

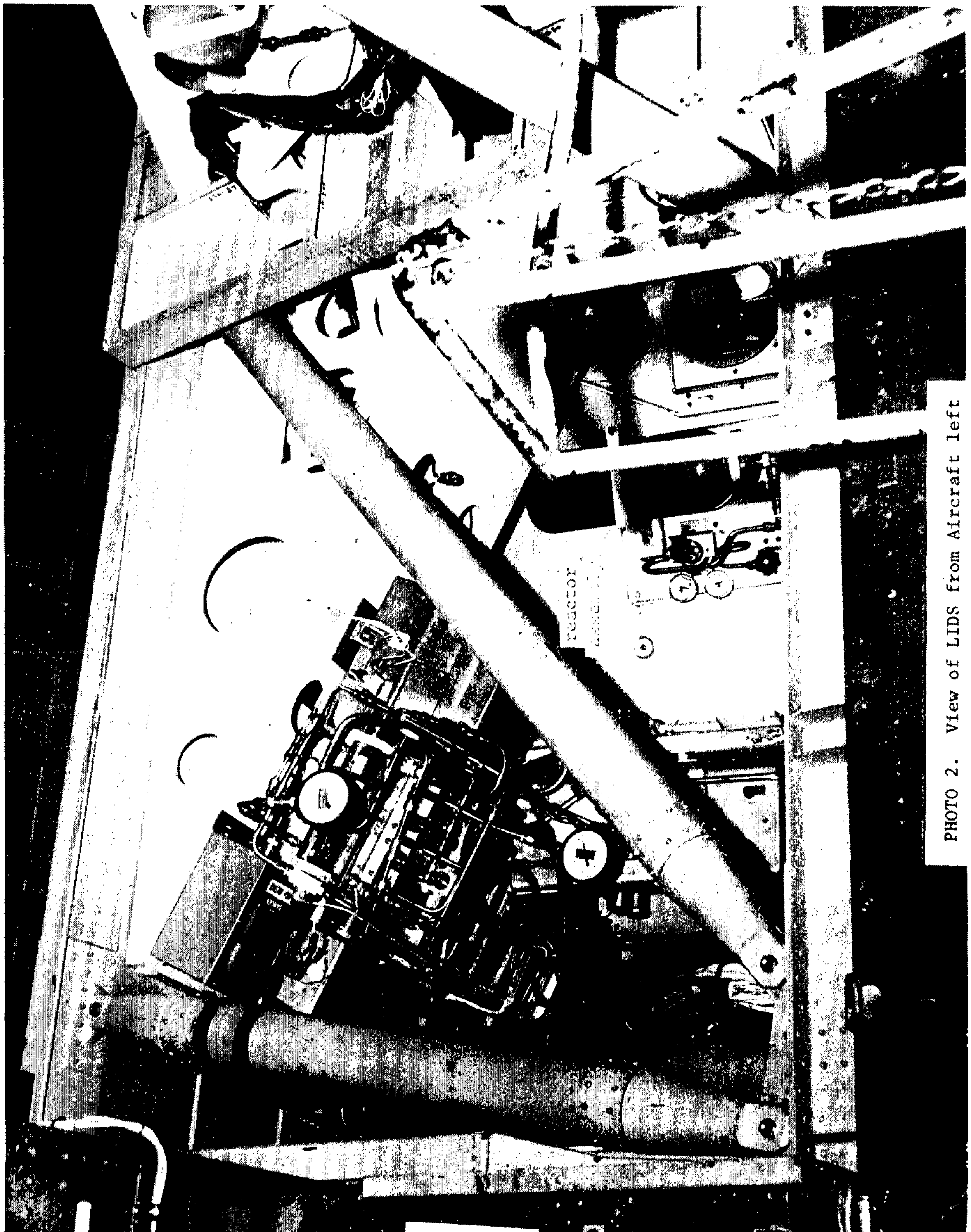


PHOTO 2. View of LIDS from Aircraft left

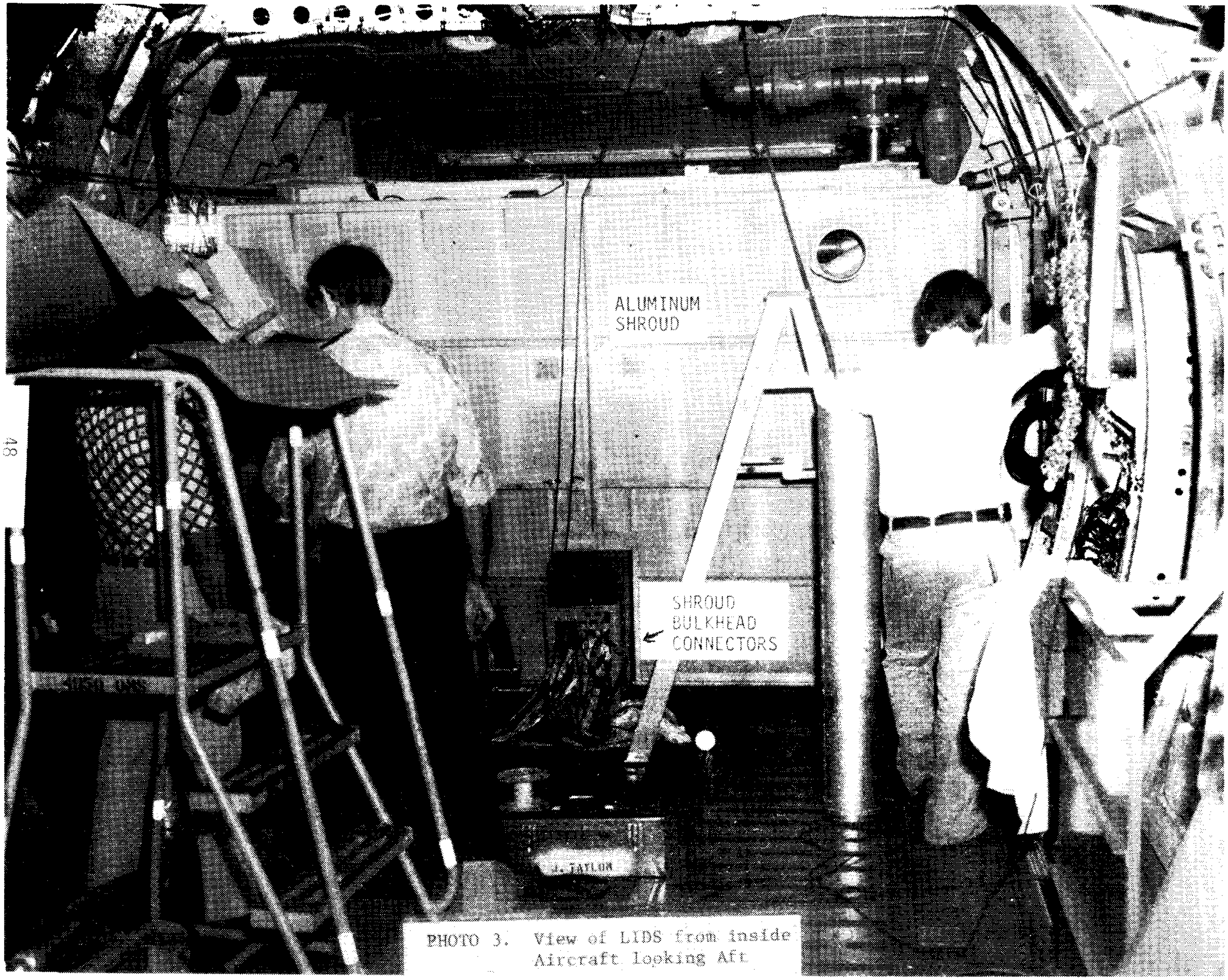


PHOTO 3. View of LIDS from inside Aircraft looking Aft

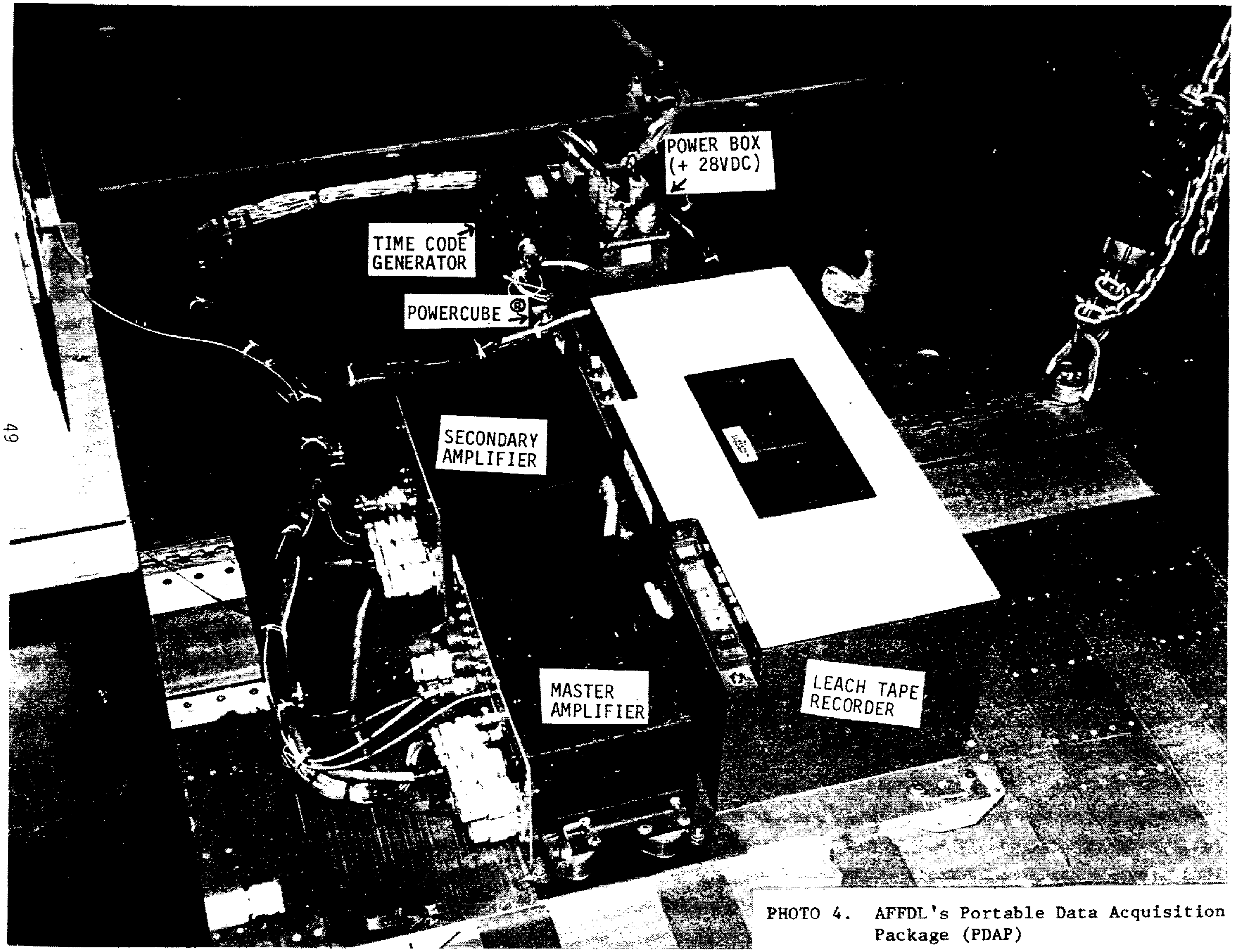


PHOTO 4. AFFDL's Portable Data Acquisition Package (PDAP)

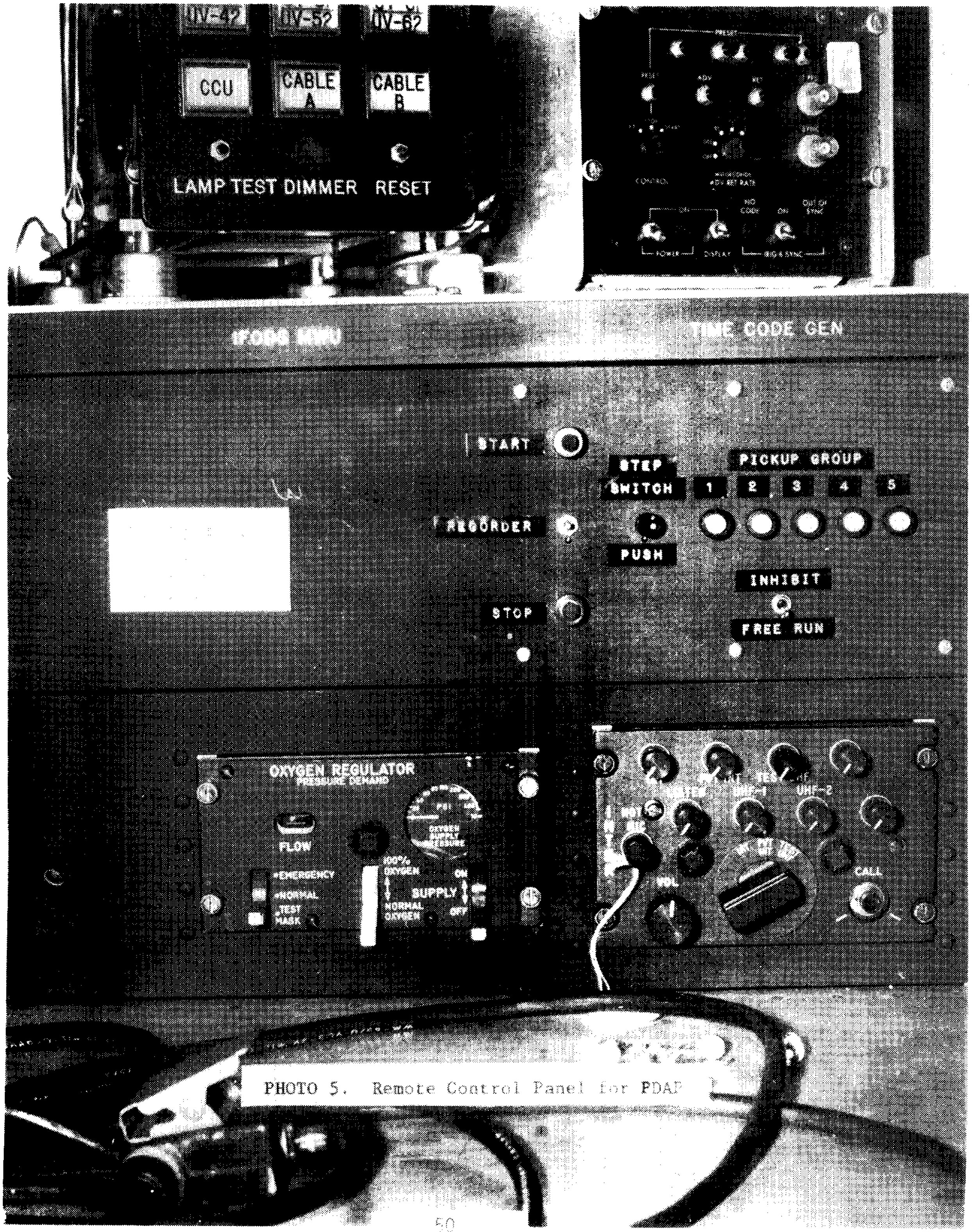


PHOTO 5. Remote Control Panel for PDAF

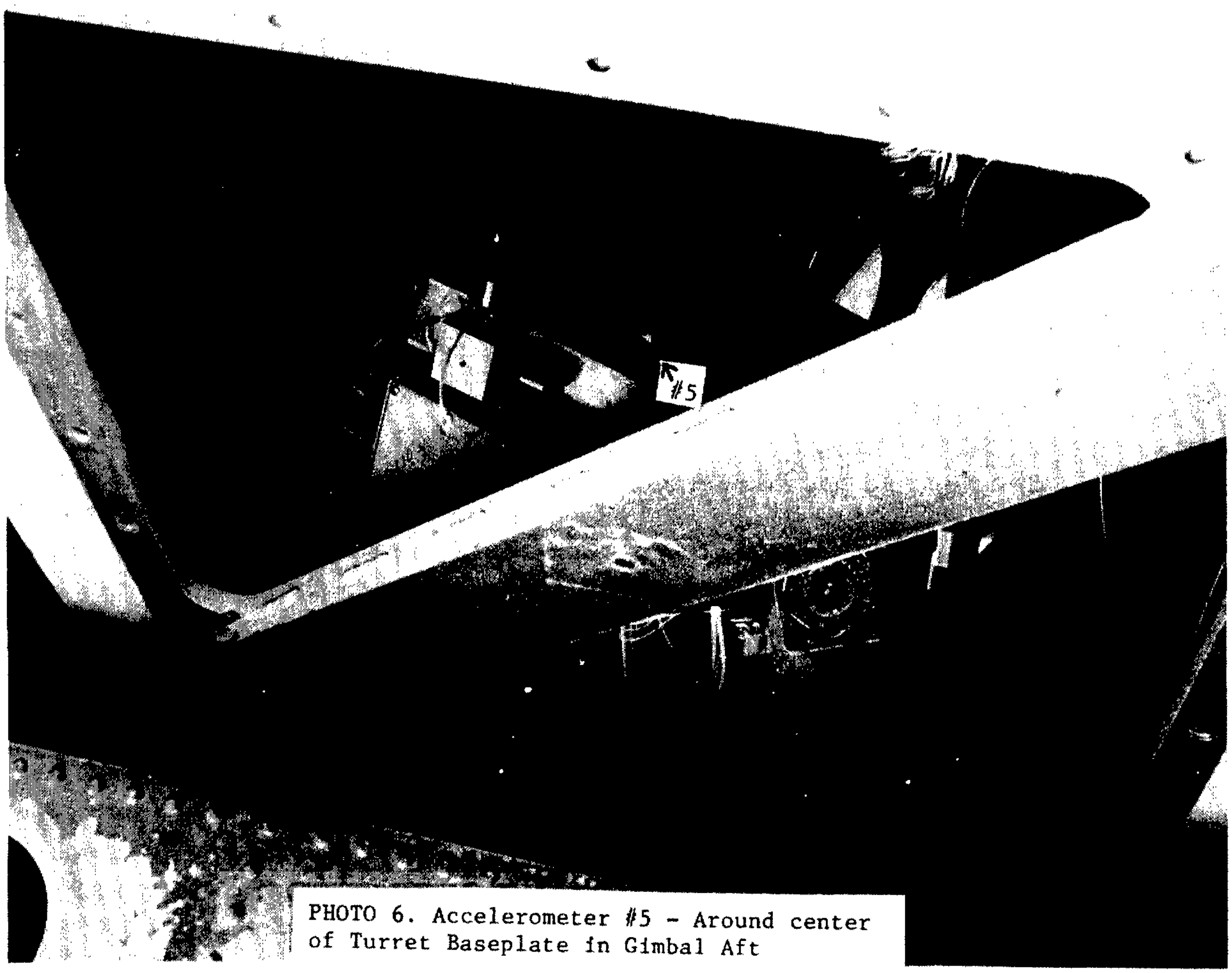


PHOTO 6. Accelerometer #5 - Around center of Turret Baseplate in Gimbal Aft

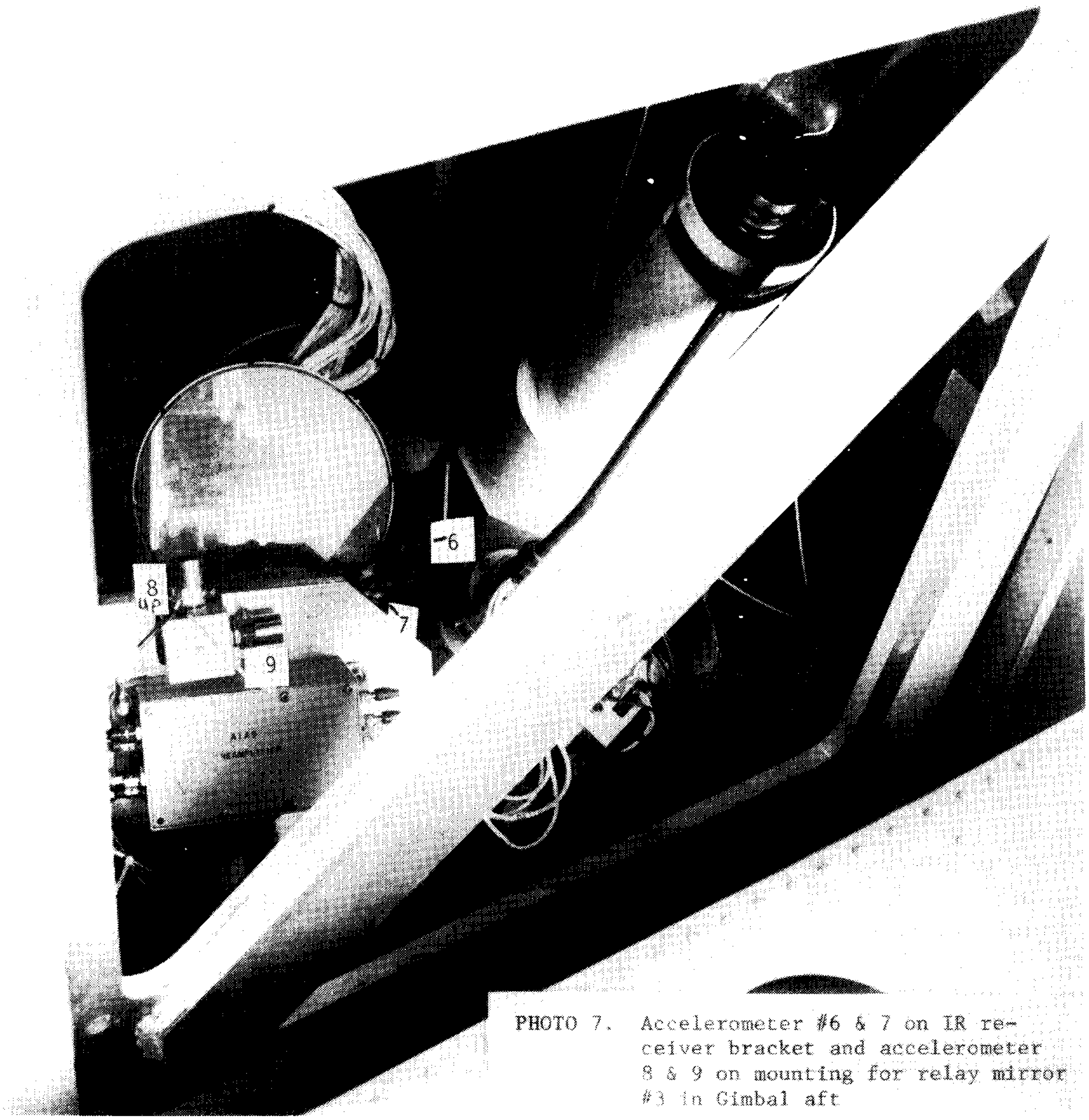


PHOTO 7. Accelerometer #6 & 7 on IR receiver bracket and accelerometer 8 & 9 on mounting for relay mirror #3 in Gimbal aft

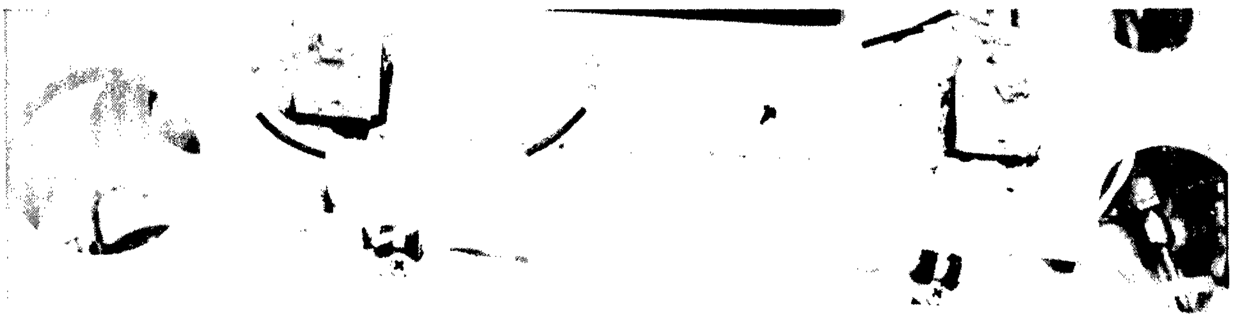
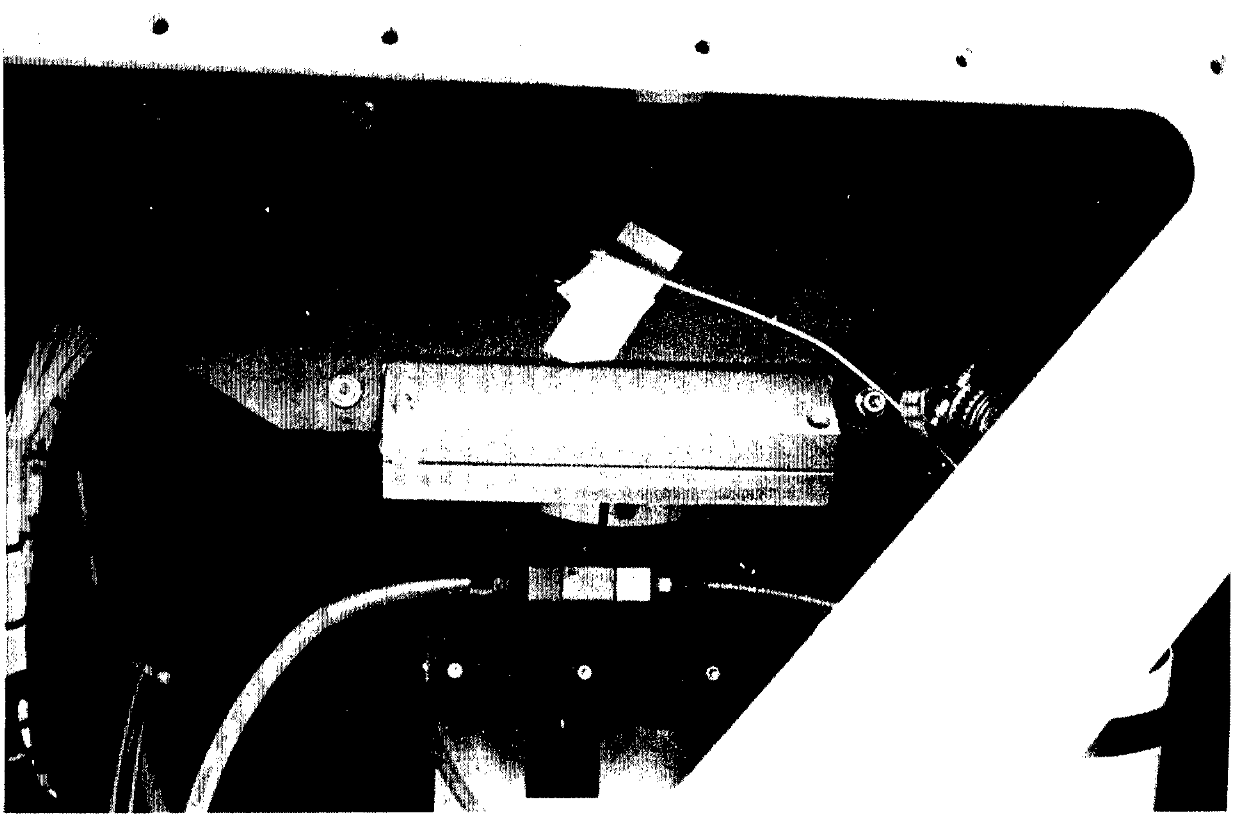


PHOTO 8. Accelerometer #10 on mounting for relay mirror #1 in Gimbal aft



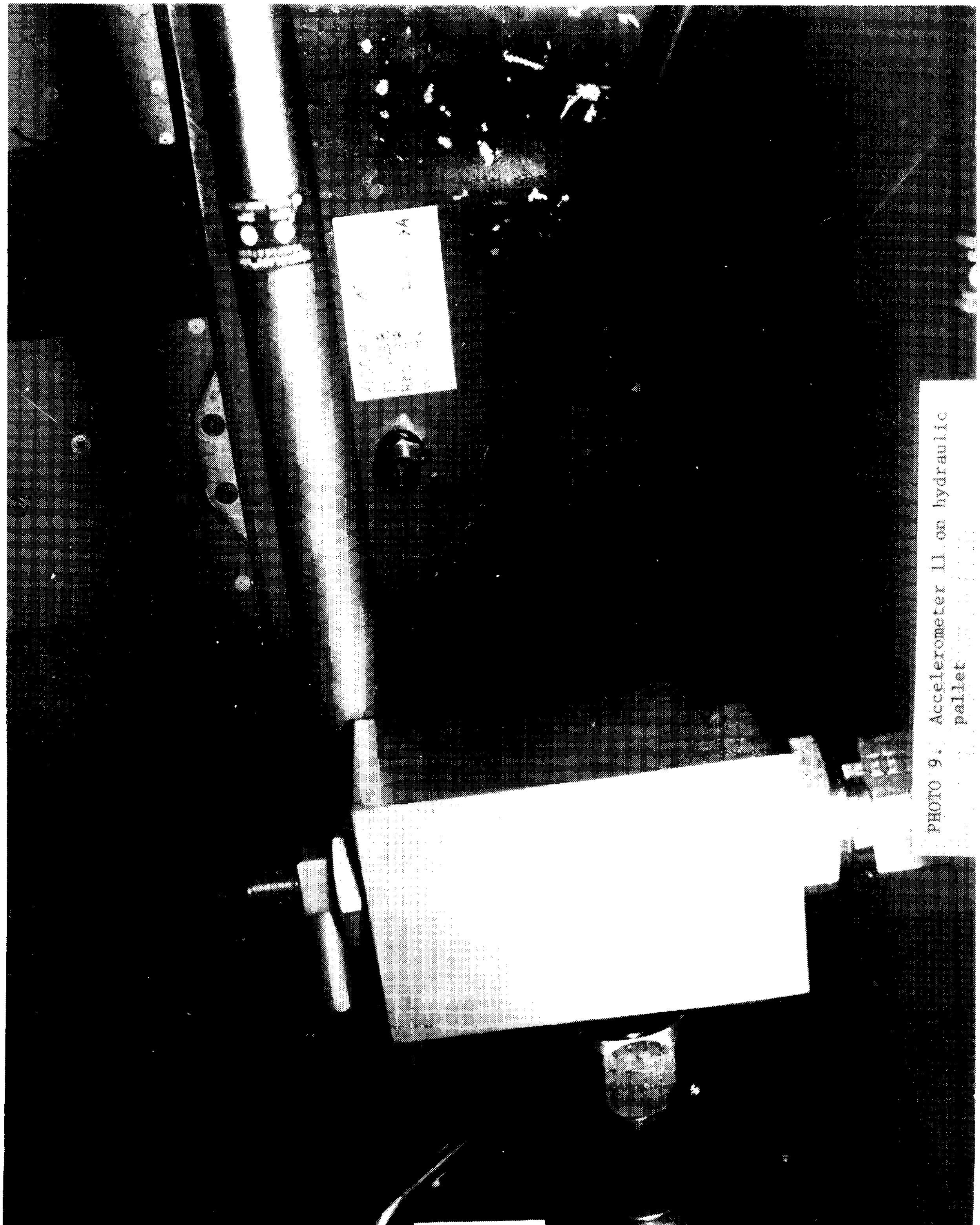


PHOTO 9. Accelerometer 11 on hydraulic pallet

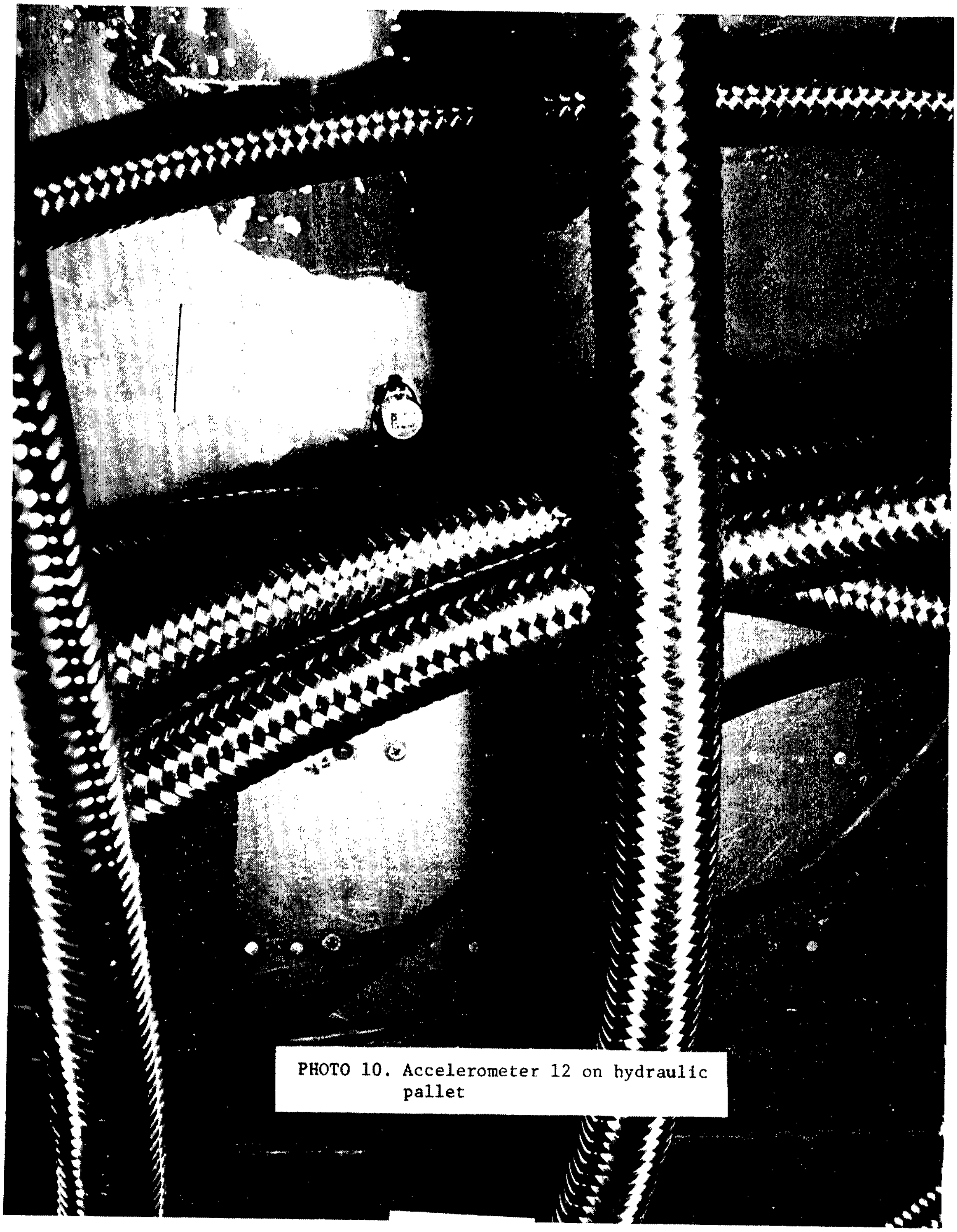


PHOTO 10. Accelerometer 12 on hydraulic pallet

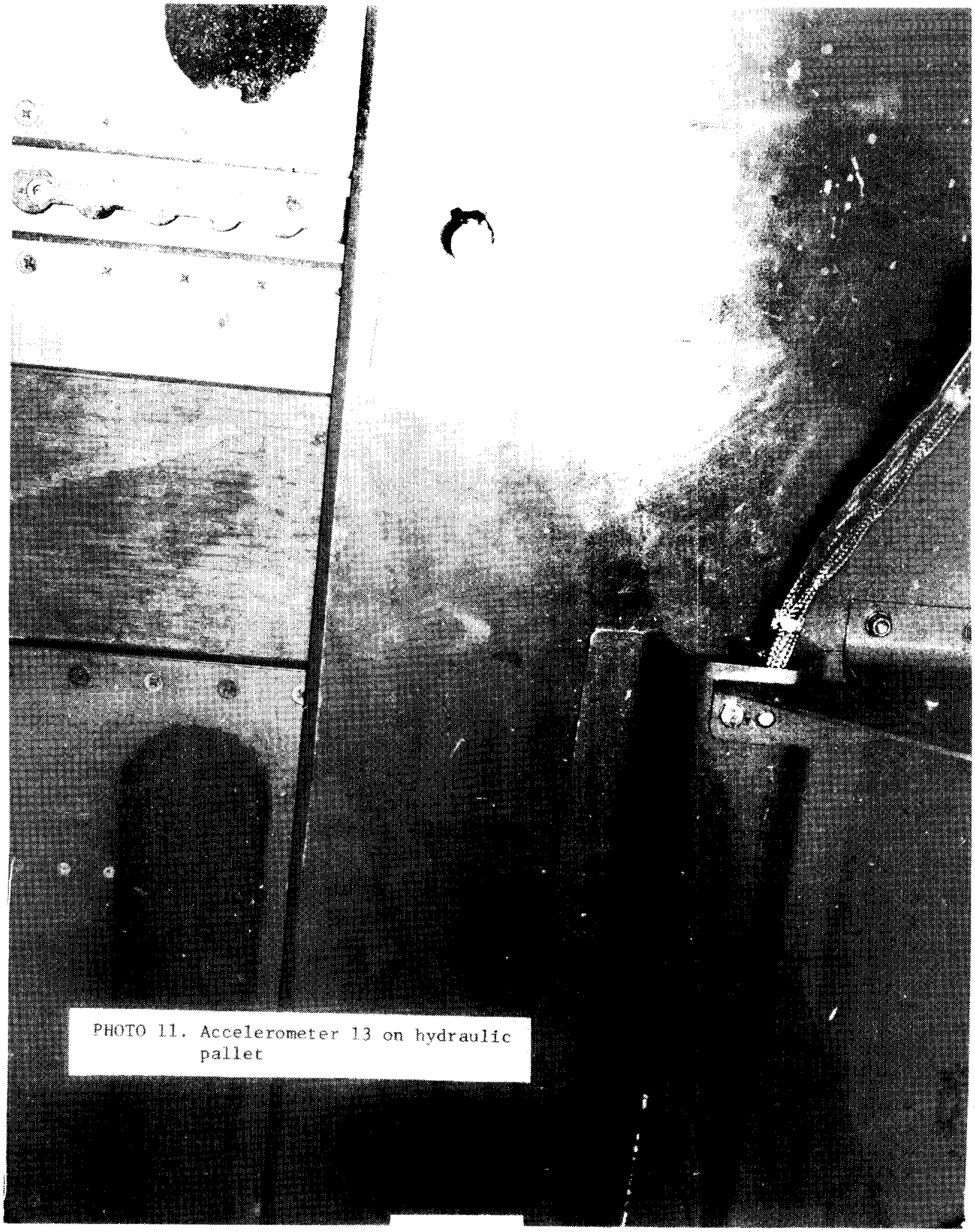


PHOTO 11. Accelerometer 13 on hydraulic pallet

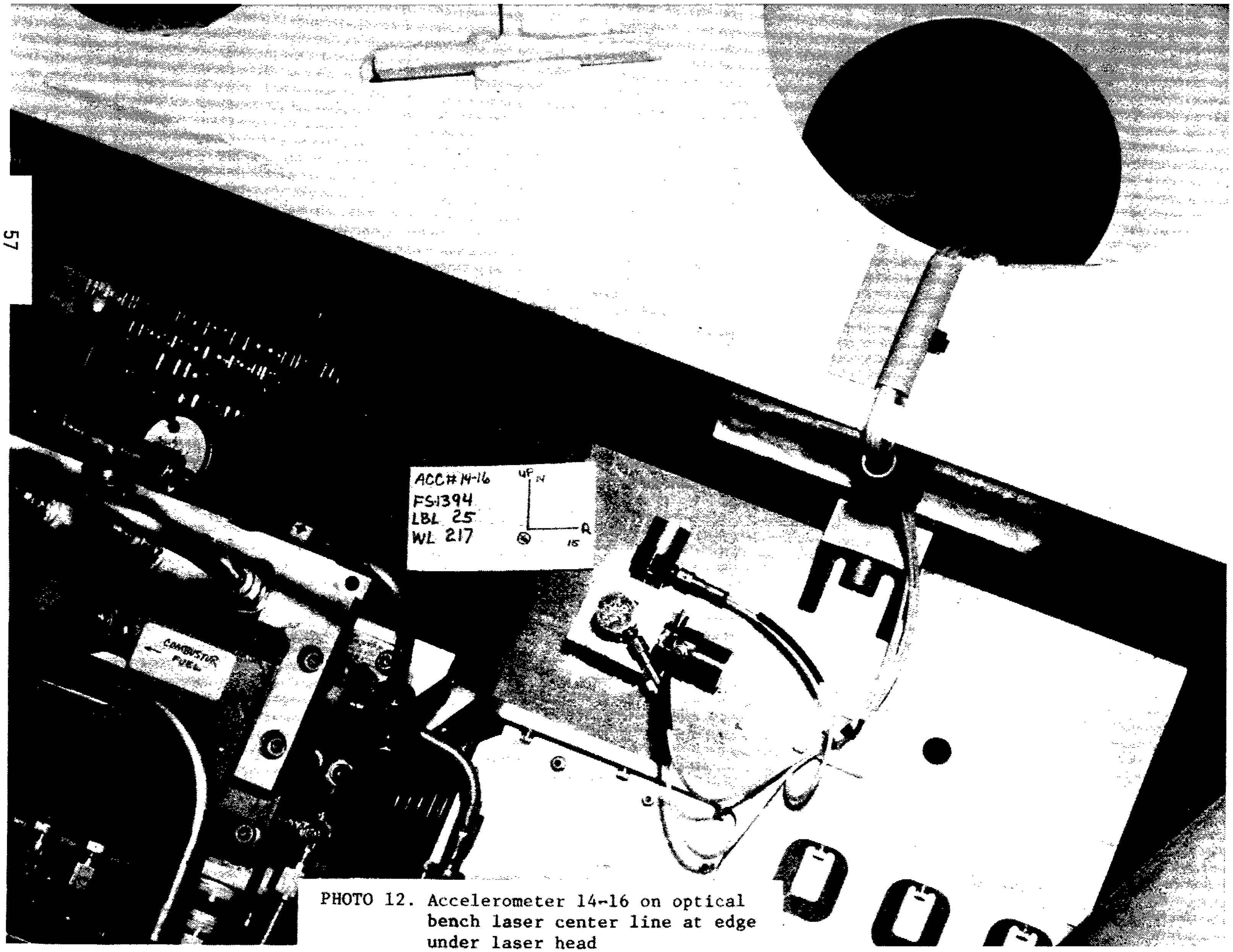


PHOTO 12. Accelerometer 14-16 on optical bench laser center line at edge under laser head

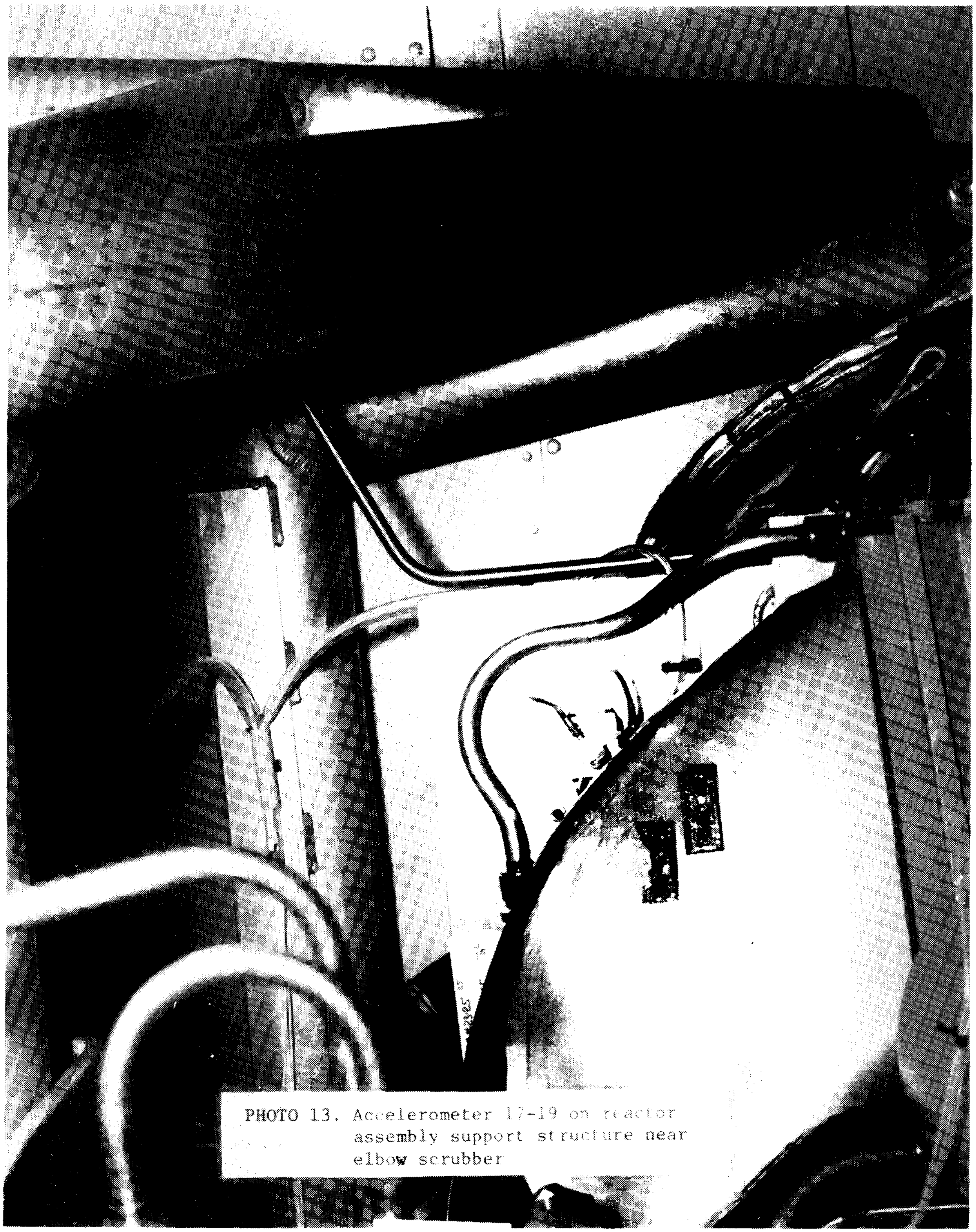


PHOTO 13. Accelerometer 17-19 on reactor assembly support structure near elbow scrubber

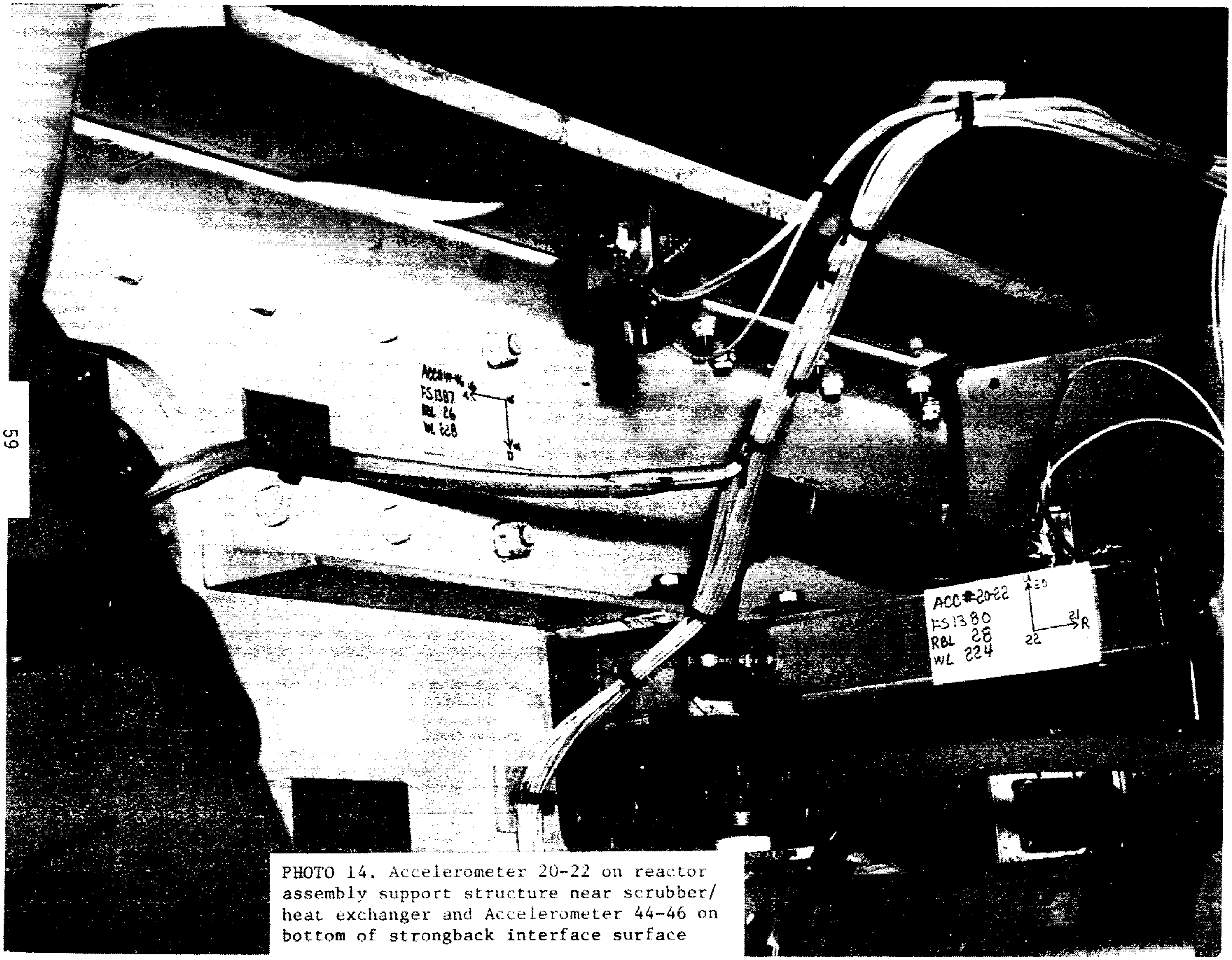
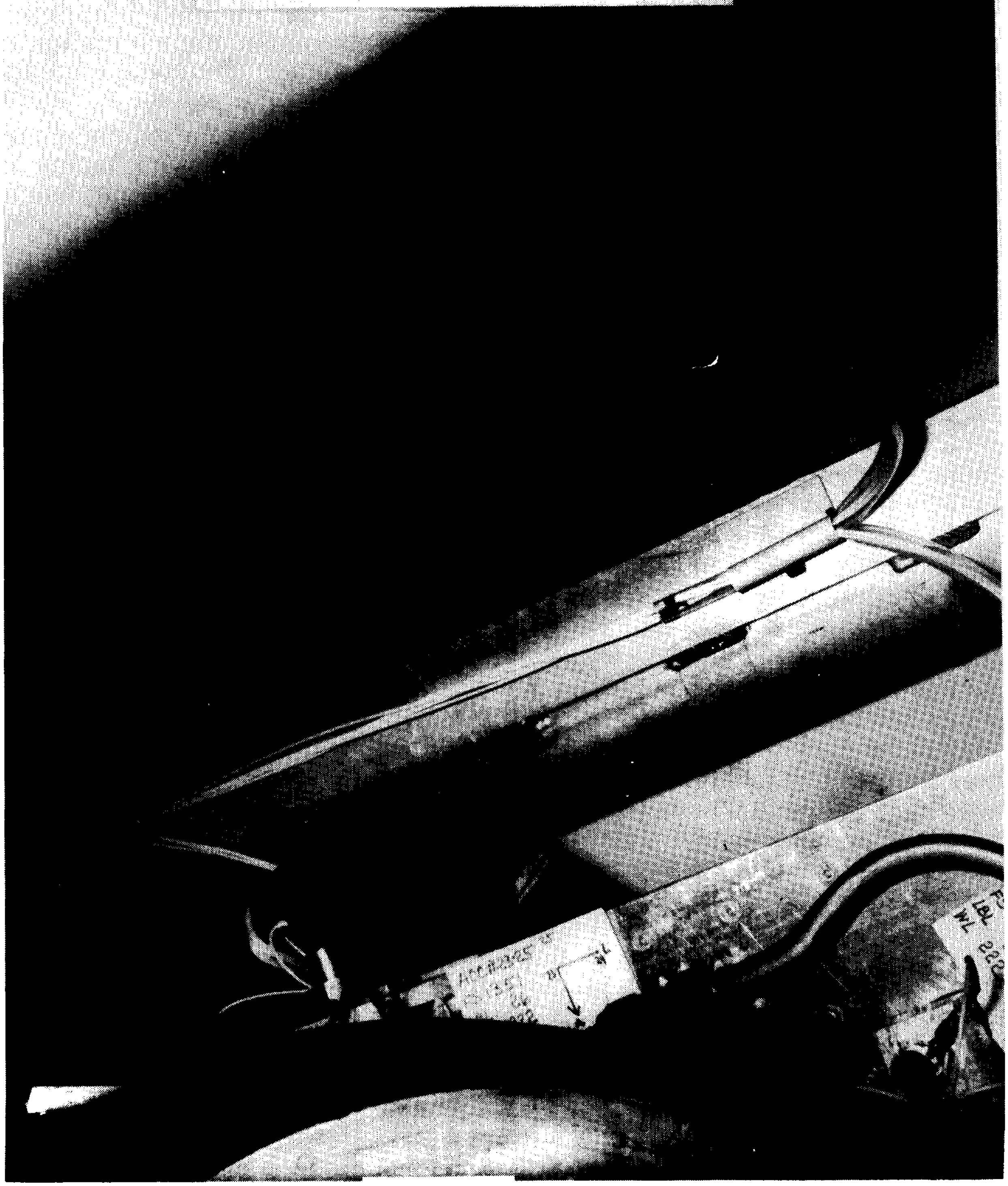


PHOTO 14. Accelerometer 20-22 on reactor assembly support structure near scrubber/ heat exchanger and Accelerometer 44-46 on bottom of strongback interface surface

PHOTO 15. Accelerometer 23-25 on reactor assembly support structure attachment to strongback



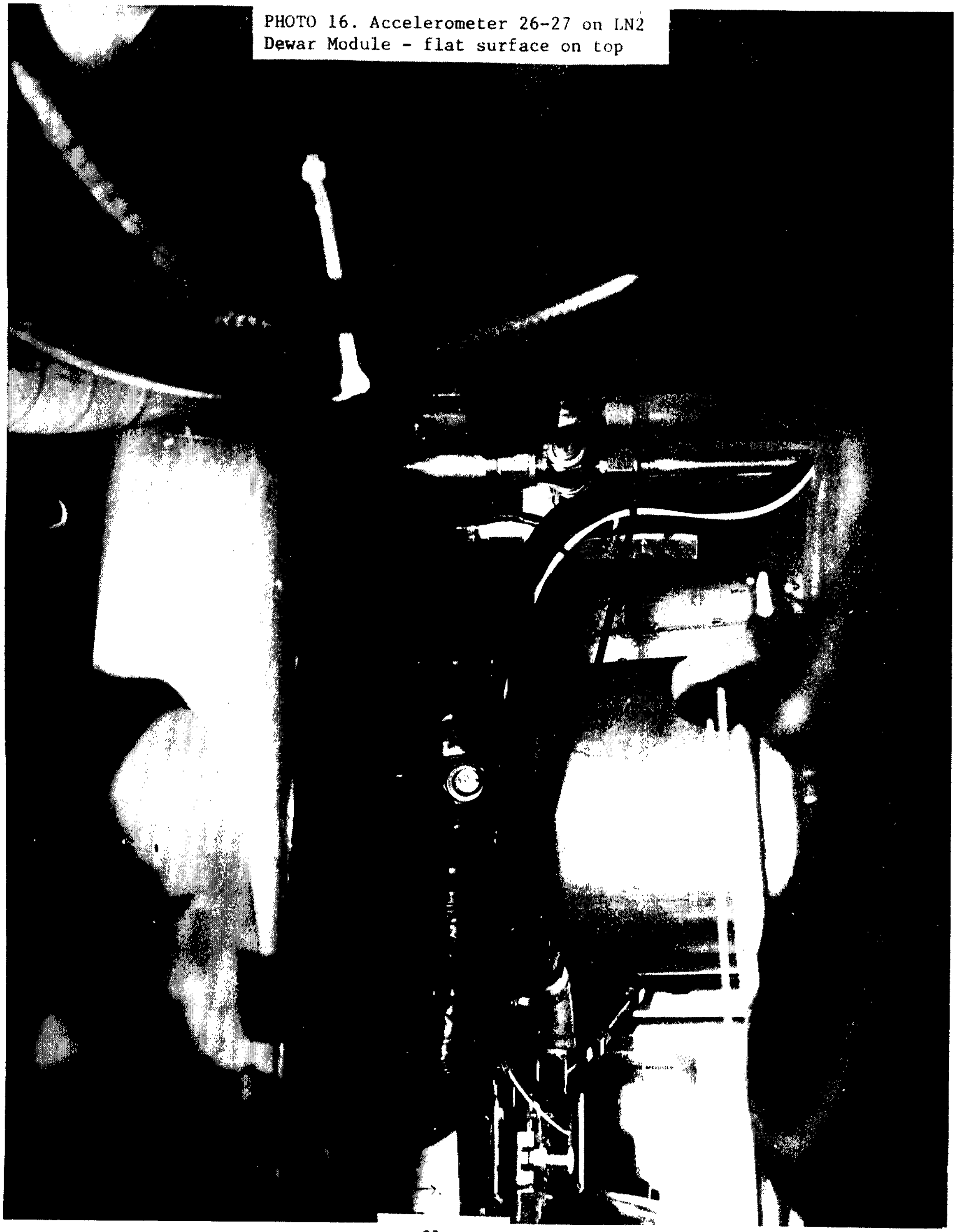


PHOTO 16. Accelerometer 26-27 on LN2
Dewar Module - flat surface on top

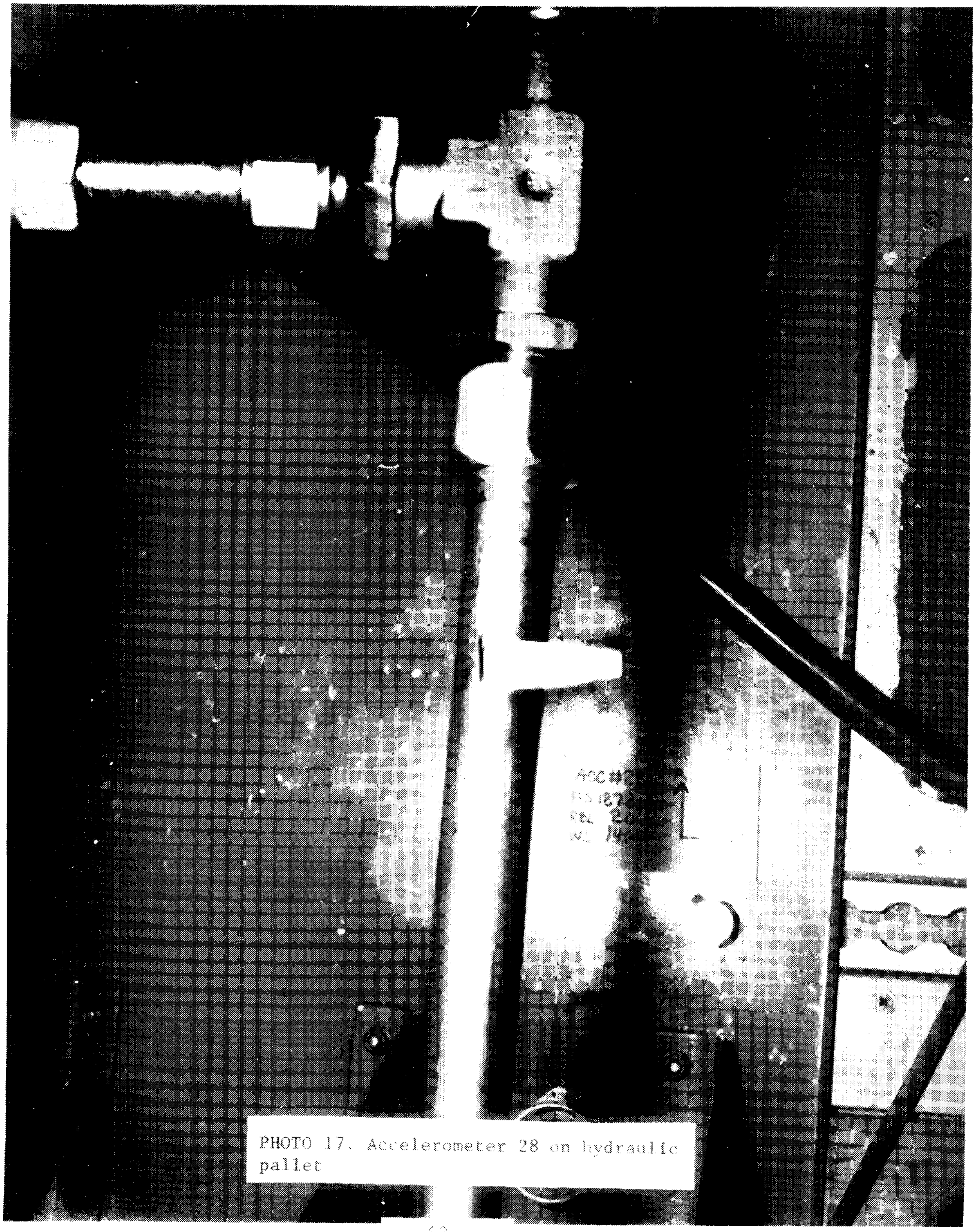


PHOTO 17. Accelerometer 28 on hydraulic pallet

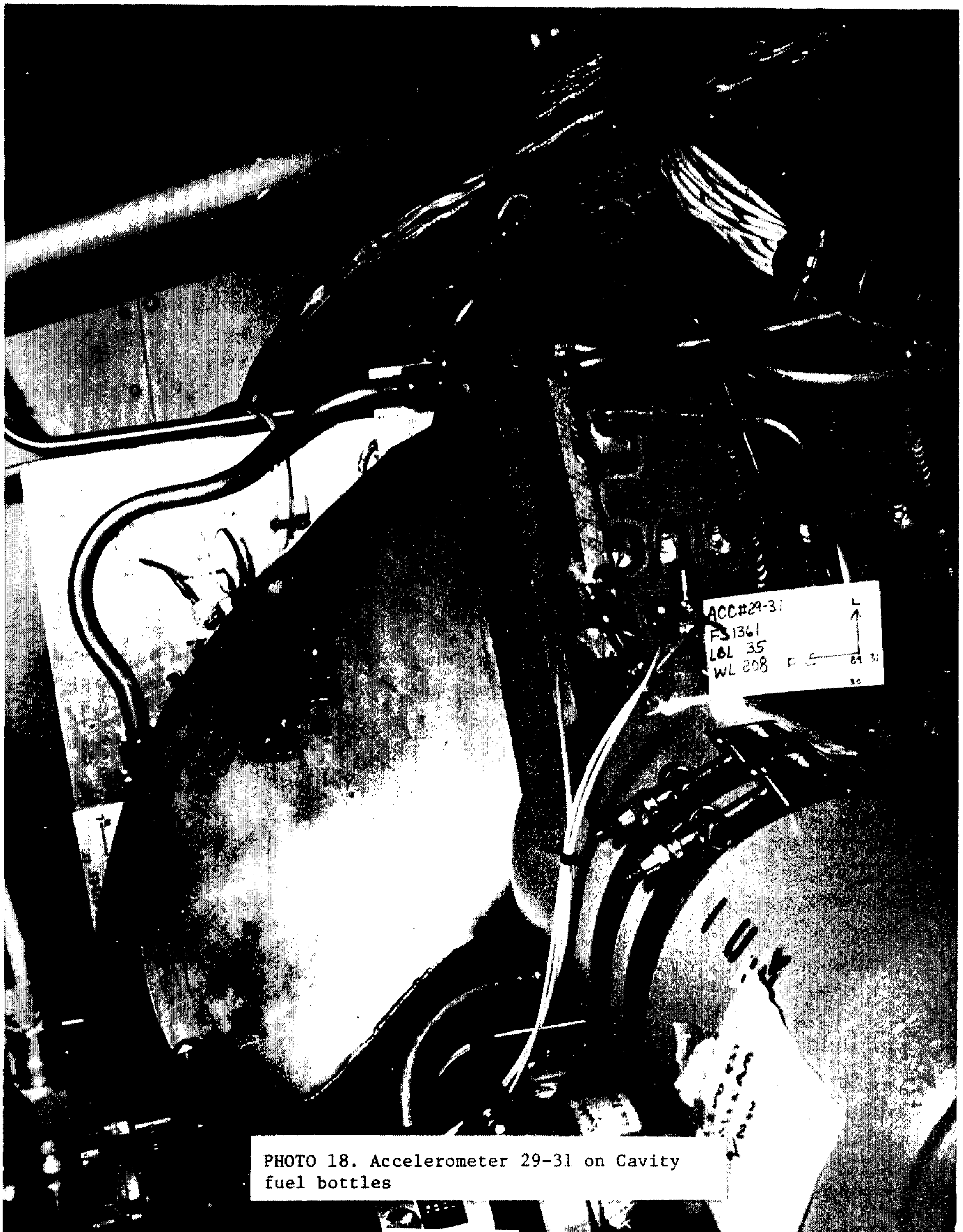


PHOTO 18. Accelerometer 29-31 on Cavity fuel bottles

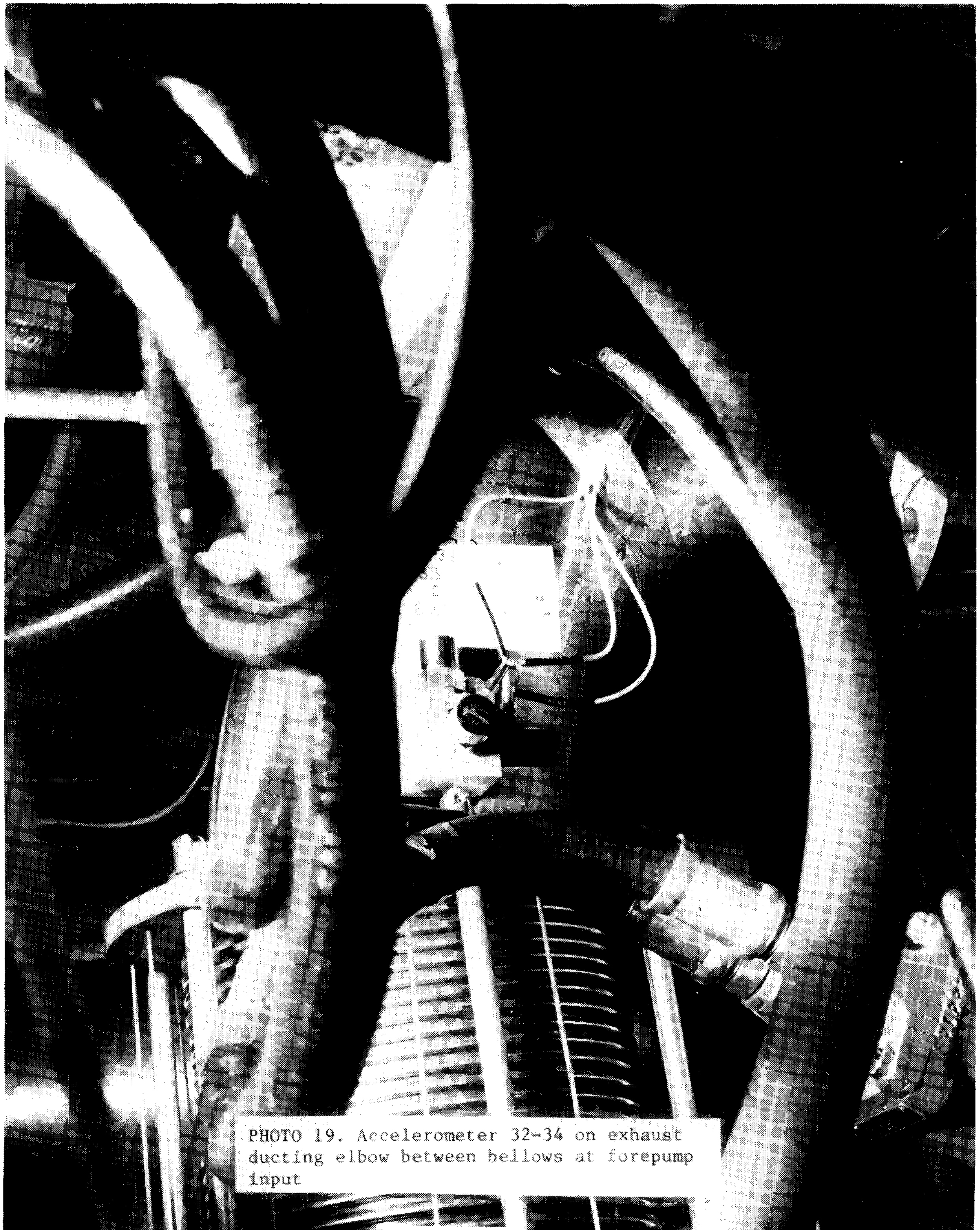


PHOTO 19. Accelerometer 32-34 on exhaust ducting elbow between bellows at forepump input

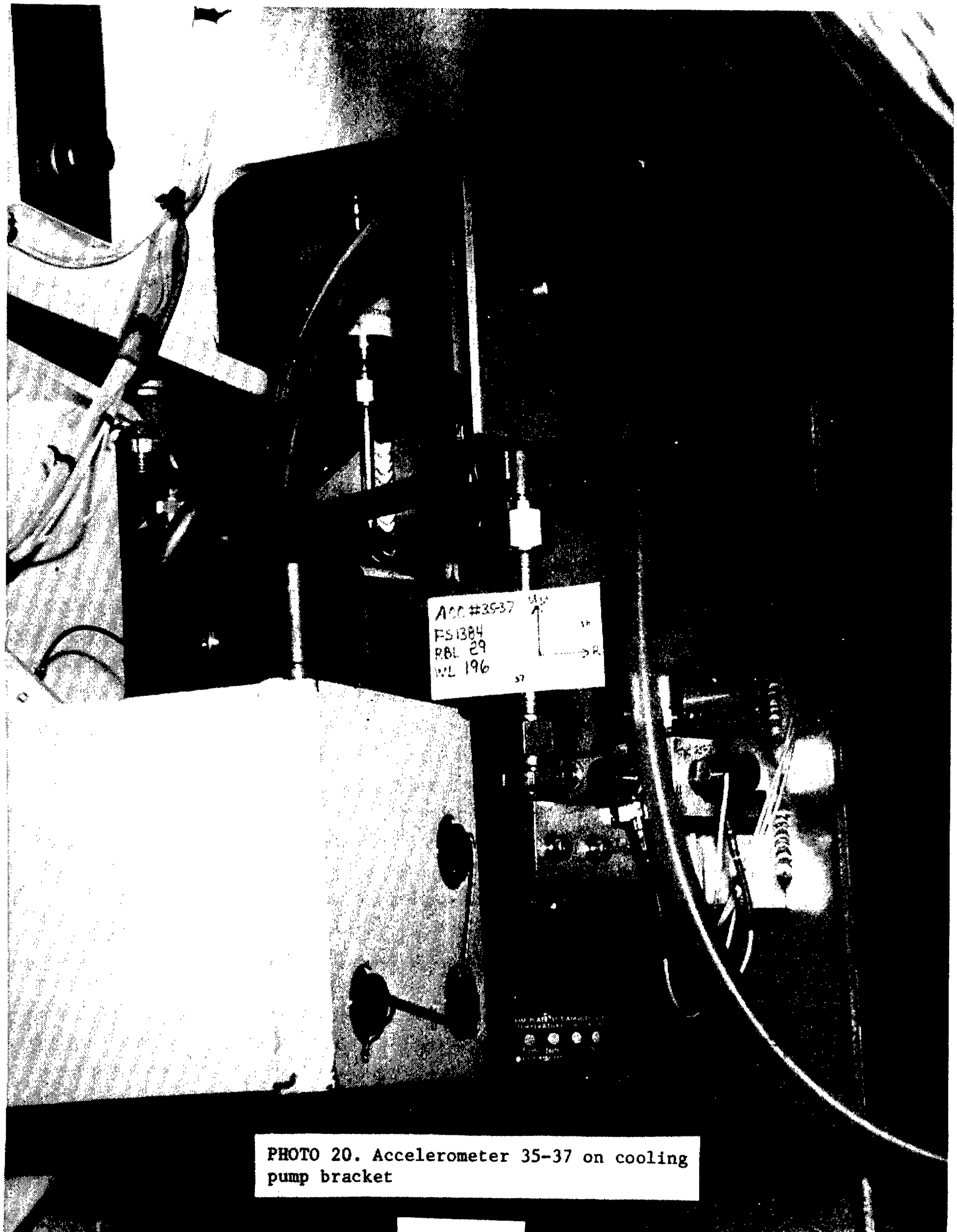


PHOTO 20. Accelerometer 35-37 on cooling pump bracket

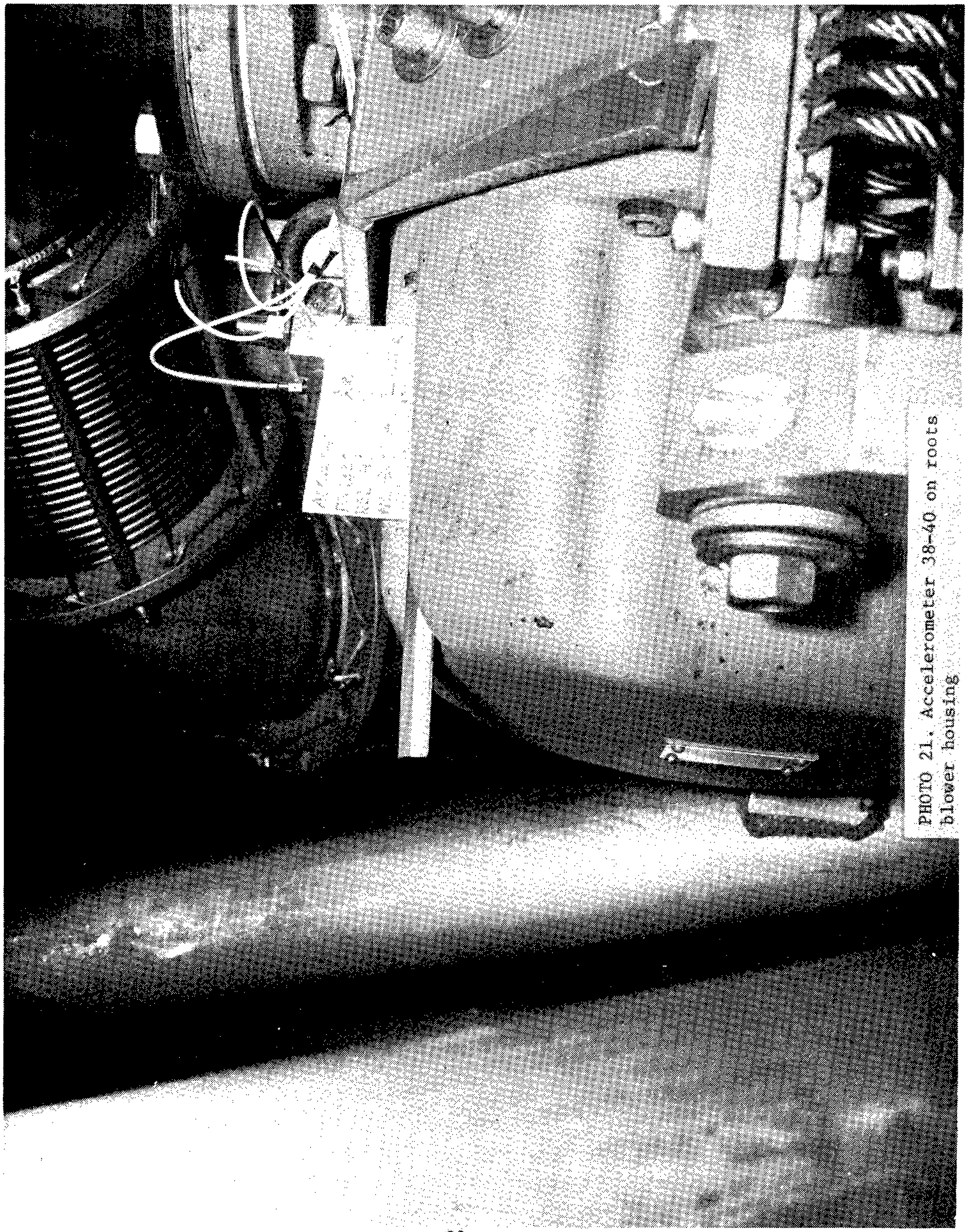


PHOTO 21. Accelerometer 38-40 on roots blower housing

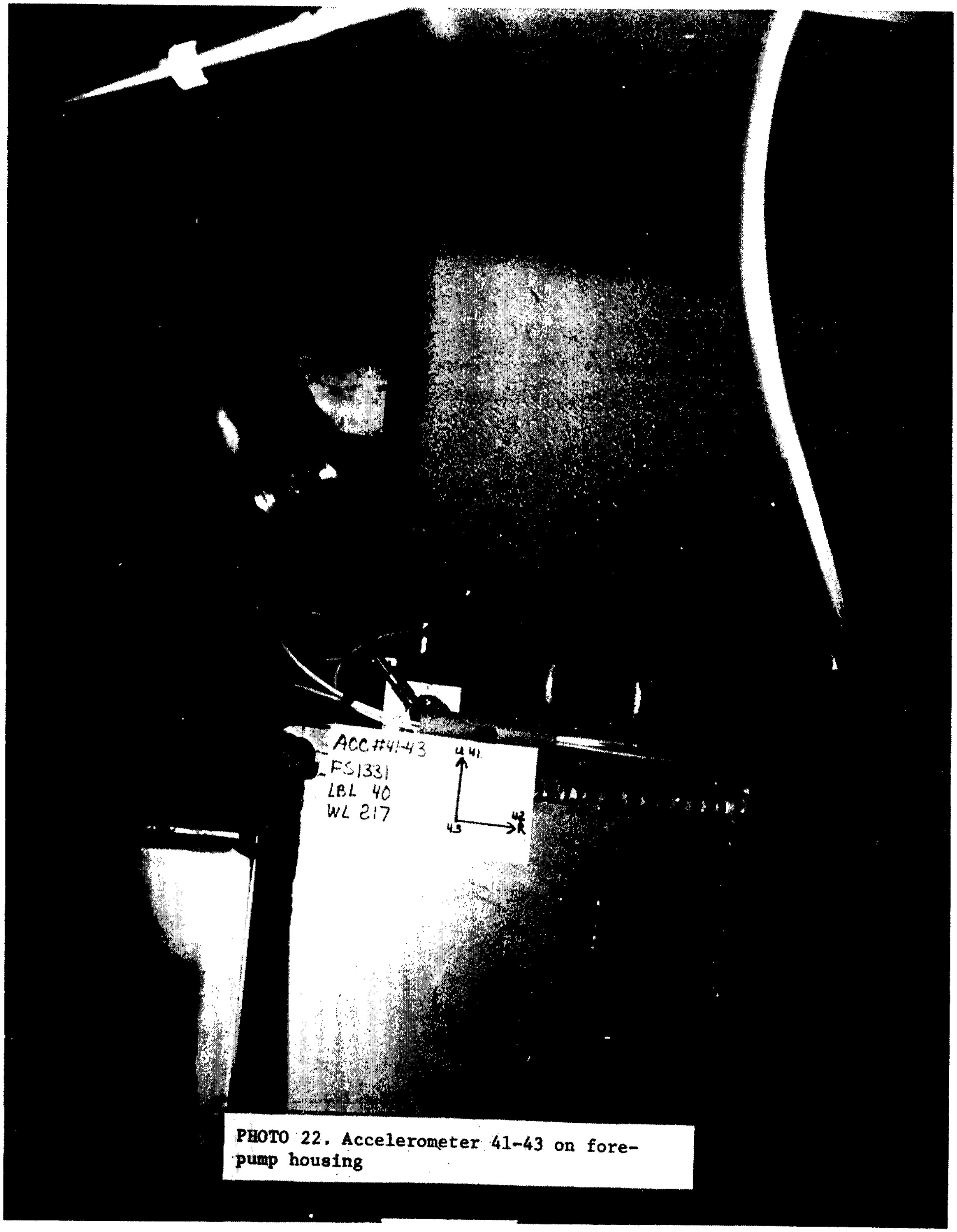


PHOTO 22. Accelerometer 41-43 on fore-pump housing

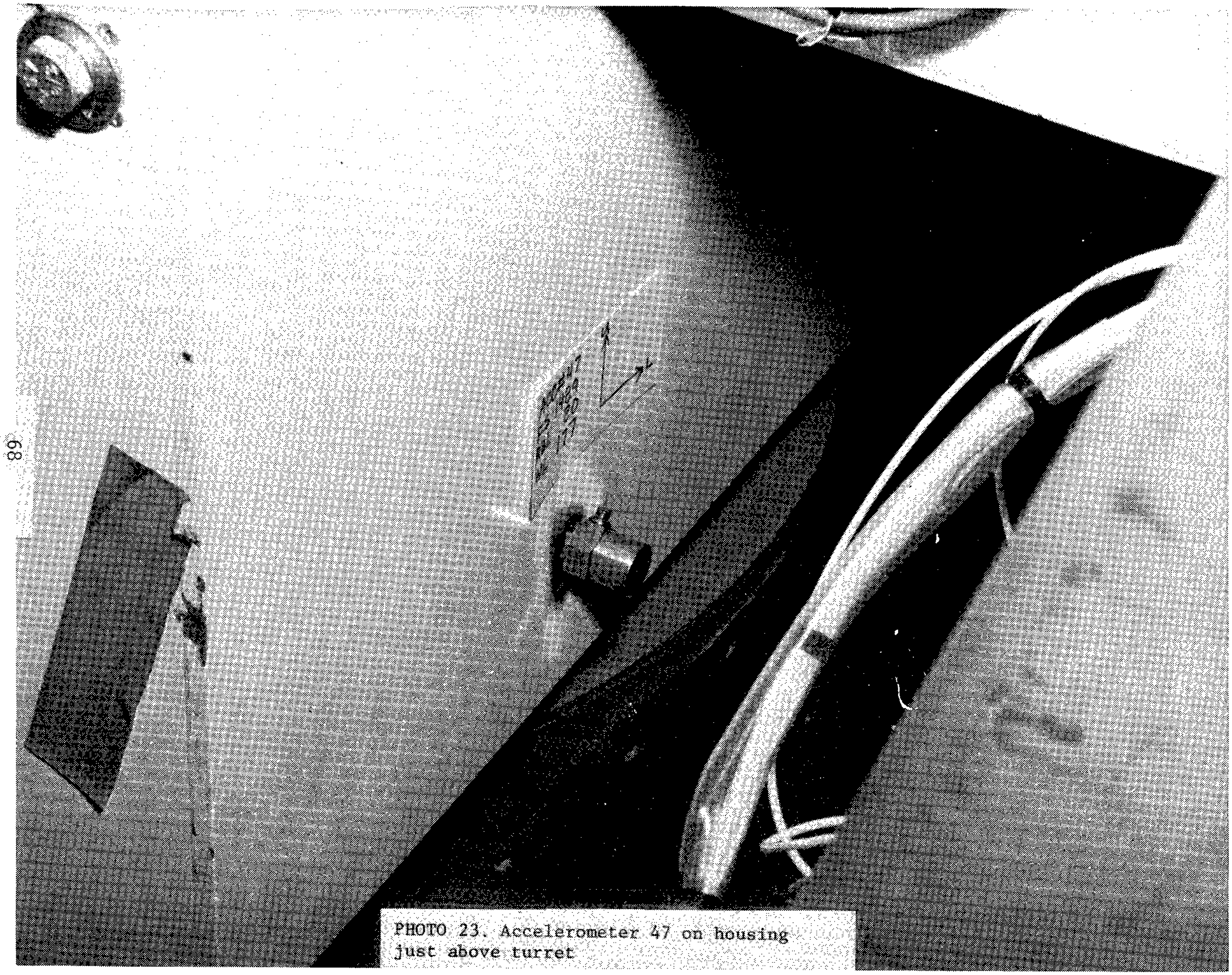


PHOTO 23. Accelerometer 47 on housing just above turret

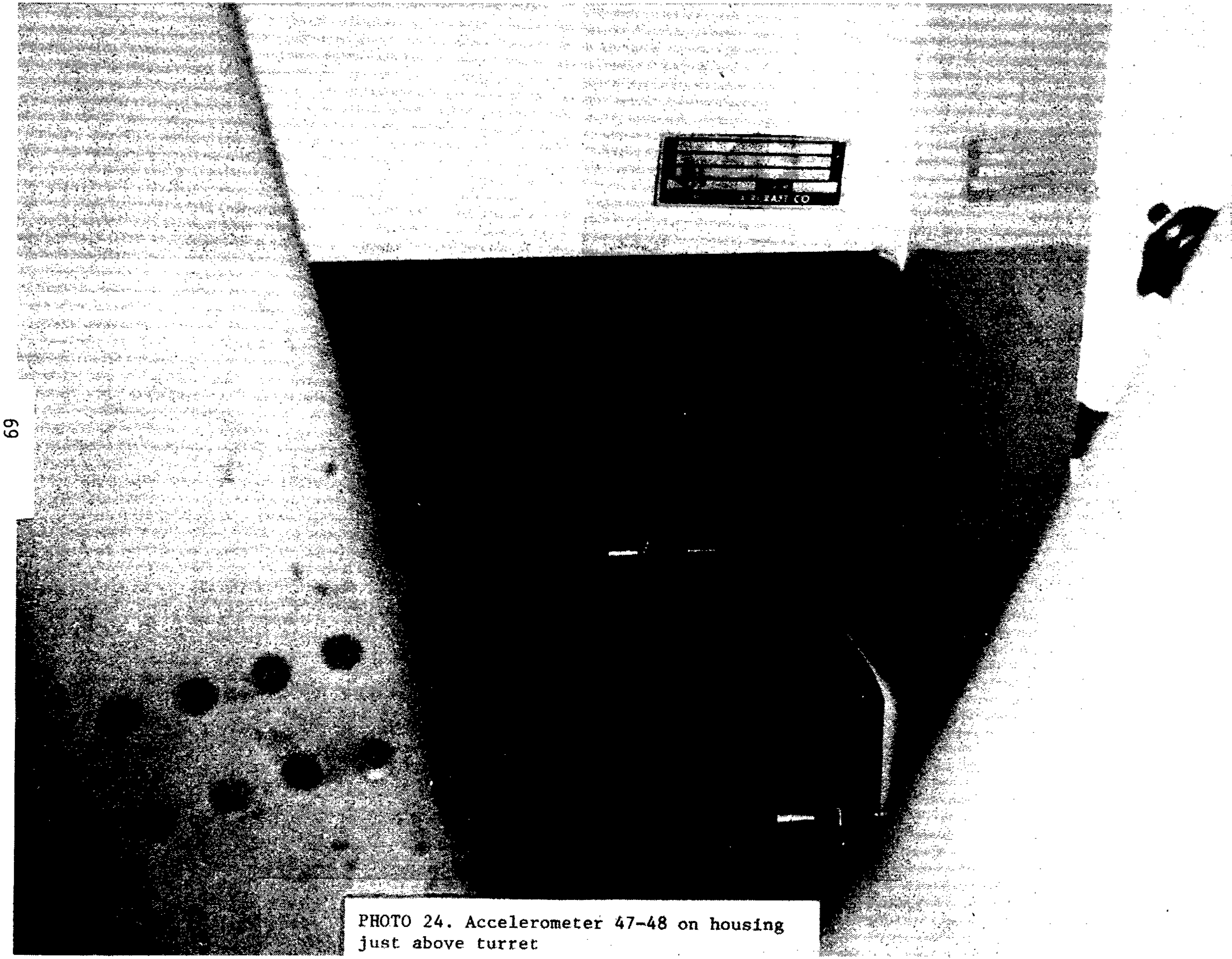


PHOTO 24. Accelerometer 47-48 on housing just above turret

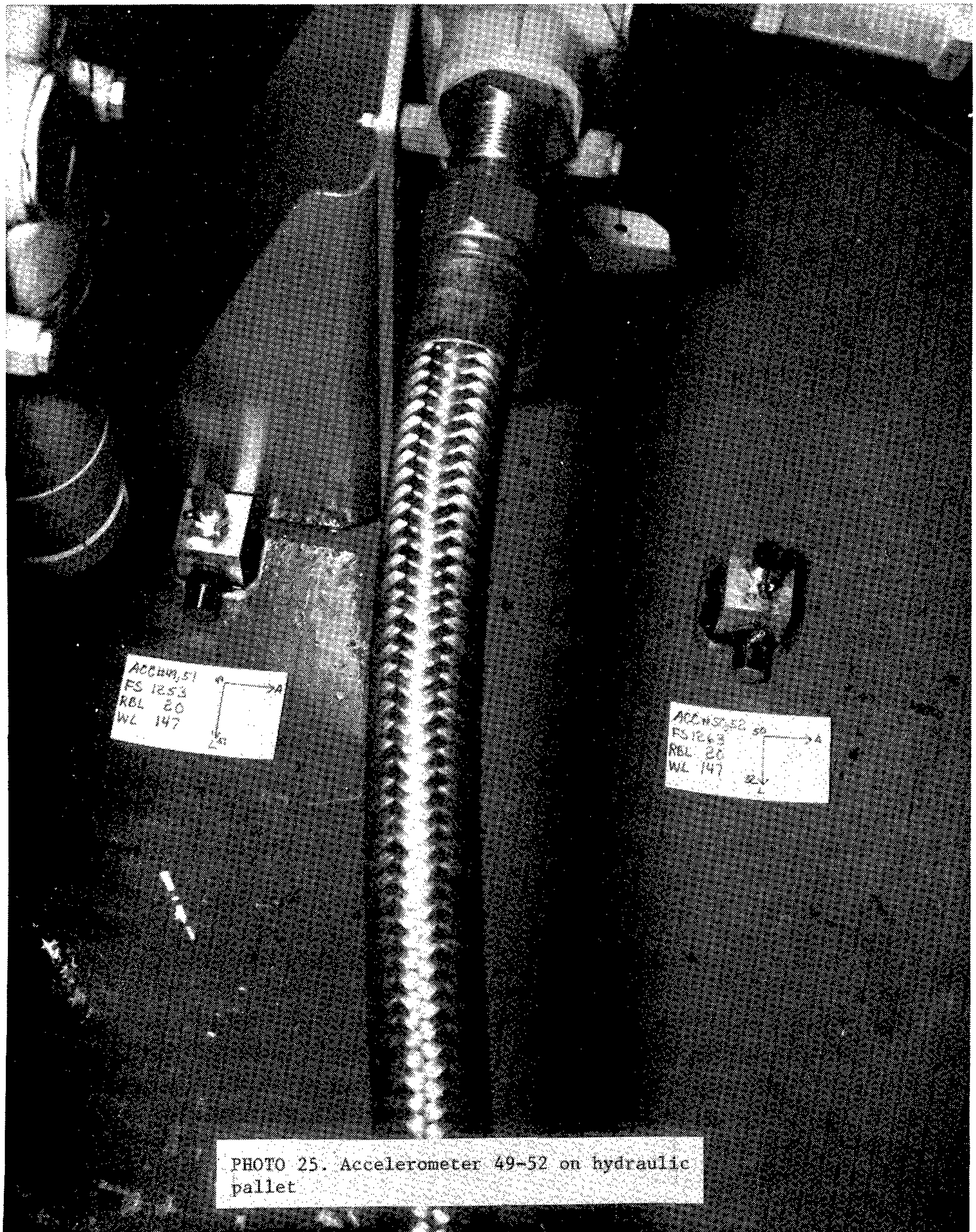


PHOTO 25. Accelerometer 49-52 on hydraulic pallet

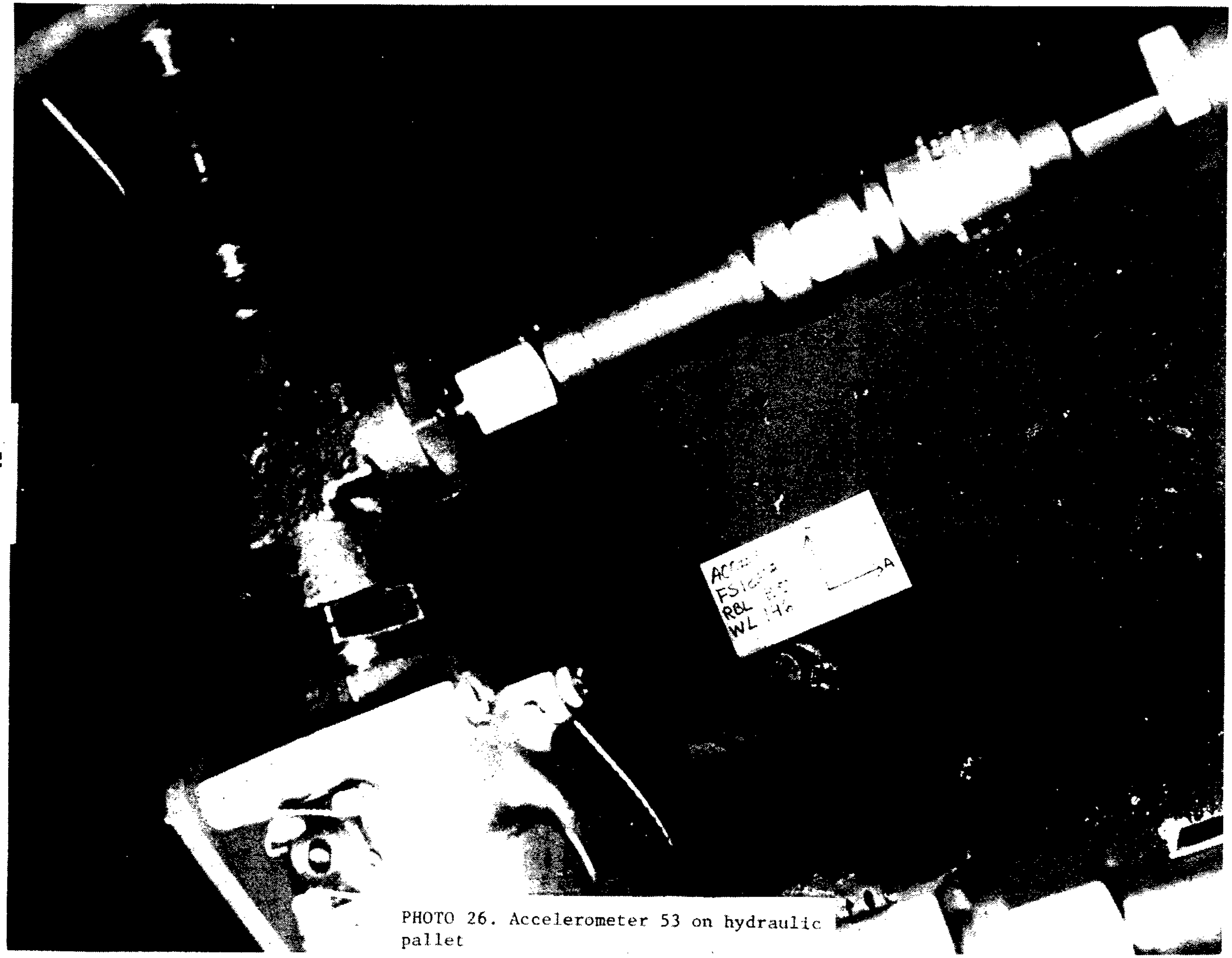


PHOTO 26. Accelerometer 53 on hydraulic pallet

PHOTO 27. Accelerometer 54 on hydraulic pallet

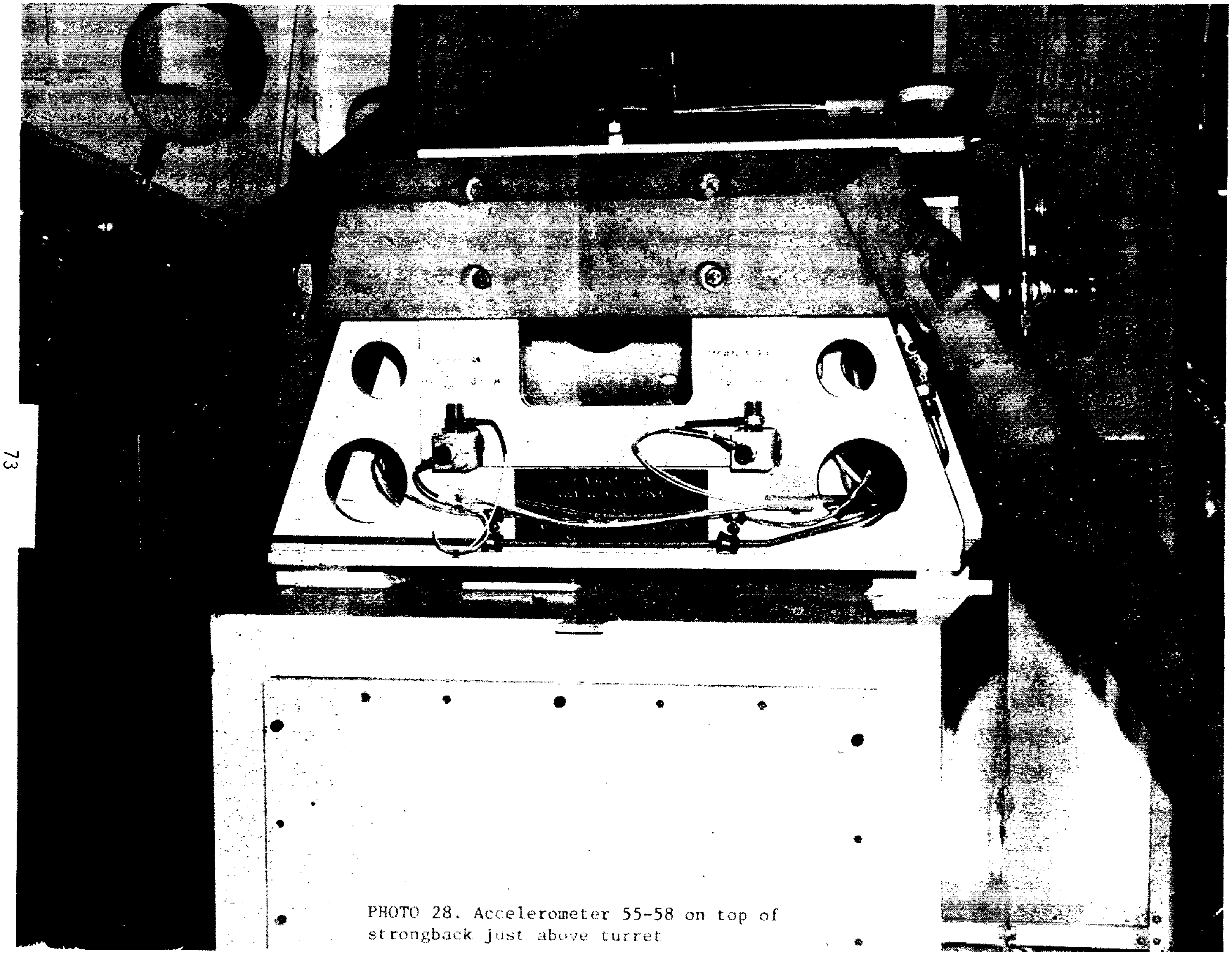


PHOTO 28. Accelerometer 55-58 on top of strongback just above turret

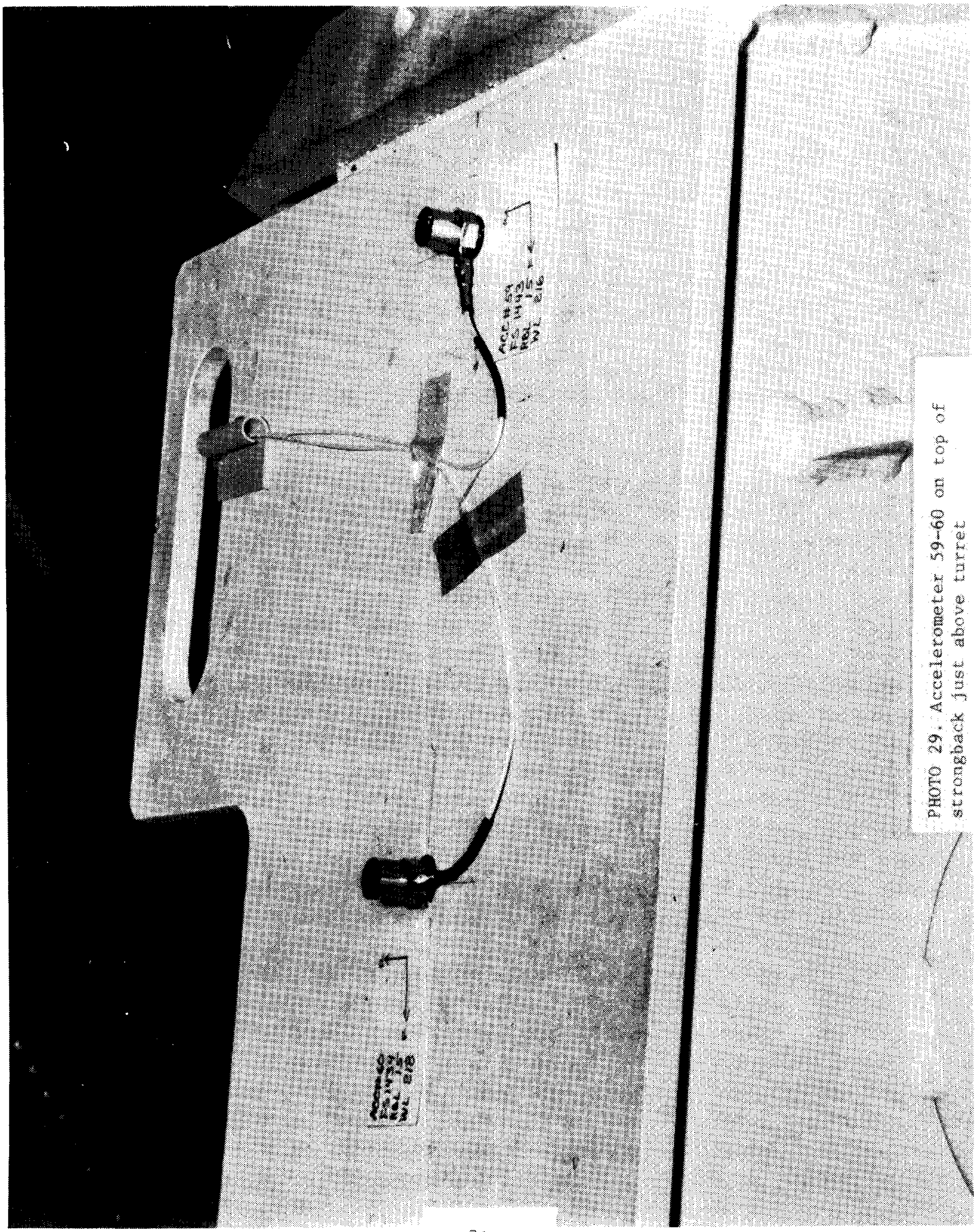


PHOTO 29. Accelerometer 59-60 on top of strongback just above turret